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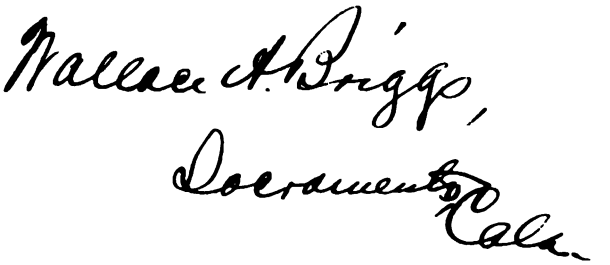
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THE

METRIC SYSTEM

OF

WEIGHTS AND MEASURES.

THE

METRIC SYSTEM

OF

WEIGHTS AND MEASURES;

AN ADDRESS DELIVERED BEFORE THE CONVOCATION OF THE UNIVERSITY OF THE STATE OF NEW YORK, AT ALBANY, AUGUST 1, 1871;

BY FREDERICK A. P. BARNARD, S. T. D., LL. D.,

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THIRD EDITION, WITH ADDITIONS AND INDEX OF TWO THOUSAND REFERENCES.

BOSTON:

Published by vote and under direction of the

AMERICAN METRIC BUREAU.

[MELVIL DEWEY, Secretary.]

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PREFACE TO THE REVISED EDITION.

The essay which, in the form of an address, occupies the principal place in this little volume, exhibited at the time of its preparation a sufficiently complete view of the progress which had been made up to that time in the effort to secure uniformity among the systems of weight and measure in use among the nations. In preparing, after the lapse of more than six years, a new edition for the use of the American Metric Bureau, it has seemed desirable to bring up the history of the movement from the point at which it was left in the original work to the present time. Two methods have suggested themselves of doing this: the first, to introduce such changes into the text of the essay itself as to make it correspond with the state of things now actually existing; and the second, to embody the facts of interest relating to the subject, which are of more recent date than 1871, in a separate paper, to be annexed as a supplement. The first plan would, on some accounts, have been best, as it would have presented the history in continuous form, and would have contributed to unity in the mode of treatment. But its adoption would have involved the necessity of suppressing those characteristics of the essay which connect it with a particular epoch in the history of the metric movement in the United States, and to which it has owed, and must continue to owe, a large proportion of any usefulness it may have possessed in forwarding that movement.

Previously to 1870 the interest felt in this country in the subject of metrological reform was confined to a few. These few had succeeded in obtaining from the national legislature some acts of legislation favorable rather for their promise than for what they effected; and these acts had been allowed to pass rather through the general apathy prevailing in regard to the subject than in consequence of any obvious desire manifesting itself among the members of Congress to promote the object they were intended to subserve. But when, after having accomplished so much, the friends of reform sought to improve their advantage by appealing to their fellow-citizens of all classes, but especially to the educators of the land, to join with them in demanding legislation of a more positive character, they aroused a spirit of opposition which had been previously dormant, and met with discouragement in some quarters in which they might reasonably have hoped to find countenance and cheer. One

of these was the University Convocation of the State of New York, a body occupying a somewhat conspicuous position in the educational world, which, after having the subject under advisement for several years, adopted resolutions disapproving the attempt to introduce the metric system of weights and measures into this country, and recommending the permanent perpetuation of the faulty system in actual use among us.

It is not to be denied that this unexpected action considerably disconcerted for the moment the advocates of metrological reform in the United States. Its consequences, nevertheless, were not wholly disadvantageous. It opened their eyes very clearly to the magnitude of the task they had undertaken, and served to kindle a zeal and stimulate a spirit of activity which might have been otherwise much more tardily awakened.

The protest of the trustees of Columbia College, of whose proceedings on the subject an account is given in the introductory portion of the following address, compelled a renewal of the discussion before the Convocation in the year following the adoption of their unfortunate resolutions, involving an agitation which continued for two years longer, during which time new resolutions, reaffirming the conclusions of the former, were urgently pressed upon that body, and others, reversing and repudiating the same conclusions, were pressed just as urgently; the result being that, in the end, the Convocation evaded a decision, and by laying both propositions on the table left itself uncommitted.

Whatever interest, therefore, this essay may have for the general reader must always depend mainly upon the place it held in this exciting controversy, and this interest would be largely impaired by any modification of its form. Its statements of accomplished facts must therefore be taken subject to correction by reference to the later history which will be found embodied in the supplement.

COLUMBIA COLLEGE, NEW YORK, February, 1879.

PREFACE.

On the eighth day of August, 1866, the Convocation of the University of the State of New York, being then in session at Albany, was addressed by the Hon. John A. Kasson, a member of the House of Representatives of the Congress of the United States from Iowa, and Chairman of a Committee of that body appointed to consider the possibility of securing a uniform system of Coinage, Weights and Measures for all nations. Congress had then recently (July 27th, 1866), passed an act legalizing the use of the metrological system known as "The Metric System of Weights and Measures," in all business transactions in the United States; and, two years earlier, a similar act had passed the British Parliament. It was known that the system had met with large acceptance on the continent of Europe, and also in the greater portion of the American continent south of our own territory; and it was also known that the use of this system was becoming more extended every year.

The aim and hope of Mr. Kasson had been that he might enlist the large body of enlightened educators forming the University Convocation, in an active effort to advance the cause of metrological reform in our country, by diffusing among the people information in regard to the Metric System; by pointing out the merits of this system; and by meeting the objections with which the proposition to naturalize it

here, like every other threatened innovation upon established usages, however in its own nature desirable or prospectively beneficent, is sure to be encountered. And the appearances at the time were certainly favorable to the fulfilment of this hope; for the address of the honorable gentleman was received with evident marks of approval.

A committee was accordingly appointed, charged with the duty of reporting on the subject to the Convocation at a future meeting. This committee consisted of the Hon. JOHN V. L. PRUYN, LL.D. (Chancellor of the University), CHARLES DAVIES, LL.D., Professor Emeritus of the Higher Mathematics in Columbia College, and ROBERT S. HALE, LL.D., one of the Regents of the University. Prof. DAVIES, who was charged with the preparation of the report, states that it originally "seemed to be the unanimous opinion of the committee that a report would be made favorable to the introduction of the [metric] system into general use;" but that reflection and inquiry led to a modification of views, especially on his own part; and that the conclusion was reached that the Convocation should not "commit itself hastily to the great and radical changes which the introduction of the metric system would occasion." It was not, therefore, until after three years of deliberation, that the committee presented their report; and the report then made, which is said to have been partial, was apparently oral.

This committee was thereupon discharged, and a new one appointed, consisting of Prof. DAVIES, Regent HALE, and Prof. JAMES B. THOMSON, LL.D. It is stated in the preface to the final report, that Prof. THOMSON did not act with the committee. The report of this reconstructed committee was presented to the Convocation at the session of August, 1870. It consisted mainly in an argument to demonstrate the inexpediency and impracticability of introducing the Metric

System of Weights and Measures into the United States. By order of the Convocation this report was published and extensively circulated.

The Trustees and Faculty of the College with which the chairman of the Committee held formerly an official, and holds still an honorary, connection, have for some years been upon the record as advocates of legislation by the Congress of the United States, favorable to the unification of the Moneys, Weights and Measures of the world. In their view, the object desired, so far as it regards Weights and Measures, is most likely to be secured through the universal acceptance of a metrological system which is already generally received; and that is the Metric System. To them it appeared that the publication of a report prepared by a gentleman in nominal connection with them, maintaining an opposite opinion, was likely to produce an erroneous impression in the public mind in regard to their own position. At a meeting therefore of the Trustees, held on the first day of May, 1871, a resolution was adopted, on motion of the Hon. SAMUEL BLATCHFORD, LL.D., Judge of the United States District Court for the Southern District of New York, requesting the President of the College to attend the meeting of the Convocation to be held in the August next ensuing, and to state to that body how far the views set forth in the report of the committee above referred to are in harmony with those entertained by the Faculty of the College.

It was in obedience to this resolution that the address contained in the following pages was prepared. The address was listened to with evidently interested attention by the Convocation; and, by the courtesy of the Regents of the University, it was immediately published, in advance of the report of the Proceedings of the Convocation, in pamphlet form. Some copies of this publication having been laid before the

Trustees of Columbia College at a meeting held on the second day of October, 1871, it was, on motion of Judge BLATCHFORD, resolved, that a revised edition of one thousand copies be printed for general circulation. In the present edition, issued in conformity with this order, some slight modifications have been made in the original text; and some additional information presumedly of interest has been appended in the form of notes.

ORIGIN AND NATURE

OF THE

METRIC SYSTEM OF WEIGHTS AND MEASURES.

No cause, since the earliest organization of civilized society, has contributed more largely to embarrass business transactions among men, especially by interfering with the facility of commercial exchanges between different countries, or between different provinces, cities, or even individual citizens of the same country, than the endless diversity of instrumentalities employed for the purpose of determining the *quantities* of exchangeable commodities. For the inconvenience and confusion resulting from this cause, but one effectual remedy can possibly be suggested; and that is the general adoption throughout the world of one common system of weights and measures. Until nearly the close of the eighteenth century, nevertheless, no movement appears to have been anywhere made, looking to the immediate or prospective application of this remedy. It was one of the projects entertained by the Constituent Assembly of France, at a time when the revolution had not yet passed into that sanguinary phase which but too soon succeeded, to engage the nations of Europe in a united effort to create, for the common use of all, a new metrological system, founded upon standards determined with scientific accuracy, and con-

structed in its details according to a scientific method. Nor, amid all the succeeding excitements attendant on the downfall of the monarchy, and the inauguration of the republic and the "Terror," was this important object ever lost sight of by the men who held successively in their hands the destinies of France. And though the convulsions which, for many successive years during that stormy period, agitated the continent of Europe, prevented the participation of all the nations in the prosecution of this great and beneficent work, still the work itself was prosecuted, though with some interruptions, to a satisfactory completion; and the result is seen to day in the Metric System of Weights and Measures; a system which, after the lapse of only three quarters of a century, has been adopted for use by more than half the inhabitants of the civilized and Christian world.

The principles according to which this system has been constructed are set forth in the following statement, adopted from the report on the subject made by the Honorable JOHN QUINCY ADAMS, Secretary of State of the United States, to the House of Representatives of the Sixteenth Congress, under date of February 22d, 1821.

1. That all weights and measures should be reduced to one *uniform* standard of linear measure.

2. That this standard should be an aliquot part of the circumference of the globe.

3. That the unit of linear measure, applied to matter in its three modes of extension, length, breadth, and thickness, should be the standard of all measures of length, surface, and solidity.

4. That the cubic contents of the linear measure, in distilled water, at the temperature of its greatest contraction,

should furnish at once the standard weight and measure of capacity.

5. That for everything susceptible of being measured or weighed, there should be only one measure of length, one weight, one measure of contents, with their multiples and subdivisions exclusively in decimal proportions.

6. That the principle of decimal division, and a proportion to the linear standard, should be annexed to the coins of gold, silver, and copper, to the moneys of account, to the division of time, to the barometer and thermometer, to the plummet and log-lines of the sea, to the geography of the earth and the astronomy of the skies; and, finally, to everything in human existence susceptible of comparative estimation by weight or measure.

7. That the whole system should be equally suitable to the use of all mankind.

8. That every weight and every measure should be designated by an appropriate, significant, characteristic name, applied exclusively to itself.

The following is the succinct account given by Mr. ADAMS, of the early history of the movement in which the Metric System had its origin:

"In the year 1790, the Prince de Talleyrand, then Bishop of Autun, distributed among the members of the Constituent Assembly of France, a proposal, founded upon the excessive diversity and confusion of the weights and measures then prevailing all over that country, for the reformation of the system, or, rather, for the foundation of a new one, upon the principle of a single and universal standard. After referring to the two objects which had previously been

suggested by Huyghens and Picard—the pendulum, and the proportional part of the circumference of the earth—he concluded by giving the preference to the former, and presented the project of a decree. First, that exact copies of all the different weights and elementary measures *used* in every town of France, should be obtained and sent to Paris. Secondly, that the National Assembly should write a letter to the British Parliament, requesting their concurrence with France in the adoption of a natural standard for weights and measures; for which purpose, Commissioners, in equal numbers from the French Academy of Sciences, and the British Royal Society, chosen by those learned bodies respectively, should meet at the most suitable place, and ascertain the length of the pendulum at the forty-fifth degree of latitude, and from it an invariable standard for all measures and weights. Thirdly, that, after the accomplishment, with all due solemnity, of this operation, the French Academy of Sciences should fix with precision the tables of proportion between the new standards, and the weights and measures previously used in the various parts of France; and that every town should be supplied with exact copies of the new standards, and with tables of comparison between them and those of which they were to supply the place. This decree, somewhat modified, was adopted by the Assembly; and, on the 22d of August, 1790, sanctioned by Louis the Sixteenth. Instead of writing to the British Parliament themselves, the Assembly requested the King to write to the King of Great Britain, inviting him to propose to the Parliament the formation of a joint commission of members of the Royal Society and of the Academy of Sciences, to ascertain the natural standard in the length of the pendulum. Whether the forms of the British Constitution, the temper of political animosity then subsisting between the two countries, or the

convulsions and wars which soon afterwards ensued, prevented the acceptance and execution of this proposal, it is deeply to be lamented that it was not carried into effect.

* * * * *

"The idea of associating the interests and the learning of other nations in this great effort for common improvement was not confined to the proposal for obtaining the concurrent agency of Great Britain. Spain, Italy, the Netherlands, Denmark, and Switzerland were actually represented in the proceedings of the Academy of Sciences to accomplish the purposes of the National Assembly. But, in the first instance, a committee of the Academy of Sciences, consisting of five of the ablest members of the Academy and most eminent mathematicians of Europe, Borda, Lagrange, Laplace, Monge, and Condorcet, were chosen, under the decree of the assembly, to report to that body upon the selection of the natural standard and other principles proper for the accomplishment of the object. Their report to the Academy was made on the 19th of March, 1791, and immediately transmitted to the national assembly, by whose orders it was printed. The committee, after examining three projects of a natural standard, the pendulum beating seconds, a quarter of the equator, and a quarter of the meridian, had, on a full deliberation, and with great accuracy of judgment, preferred the last, and proposed that its ten-millionth part should be taken as the standard unit of linear measure; that, as a second standard of comparison with it, the pendulum vibrating seconds at the forty-fifth degree of latitude should be assumed, and that the weight of distilled water at the point of freezing, measured by a cubical vessel in decimal proportion to the linear standard, should determine the standard of weights and of vessels of capacity."

This report having received the sanction of the assembly,

committees of the Academy of Sciences were appointed to make with all the necessary precision the determinations upon which were to rest the standard units of the new metrological system. The most laborious of these determinations consisted in the trigonometrical measurement of an arc of the meridian extending through France from Dunkirk to Barcelona; an operation which occupied seven years. The design of this was to determine with exactness the length of the linear base, called the METRE. But the assembly did not wait for the completion of this great work before giving to the system a legal and a practical existence; the length of the degree of latitude being already known with a sufficiently near approach to exactness to make any possible error of the metre founded upon it entirely insensible for the ordinary purposes of life. The system was therefore provisionally established by a law of the 1st of August, 1793; and the nomenclature which now distinguishes it was adopted on the 18th Germinal, An. III., (7th April, 1795).

In the seventh year of the Republic (1799) an international commission was assembled at Paris, on the invitation of the government, to settle, from the results of the great Meridian Survey, the exact length of the "definitive metre." In this commission were represented the governments of France, Holland, Denmark, Sweden, Switzerland, Spain, Savoy, and the Roman, Cisalpine and Ligurian Republics. After the completion of its labors, the commission proceeded on the 4th Messidor, An. VII. (22d June, 1799), to deposit, at the Palace of the Archives, in Paris, the standard metre-bar of platinum, which represents the linear base of the system; and the standard kilogramme weight, also of platinum, which represents the unit of metric weights.

Of these prototype standards, numerous copies have been

taken, which, after having been compared with the originals with the severest exactness, have been made standards of reference and verification in the various countries in which the system has been adopted.

THE METRIC SYSTEM, founded on the metre as the unit of length, has four other leading units, all connected with and dependent upon this. Hence we have—

1. The METRE, which is the unit of measures of length.

2. The ARE, which is the unit of measures of surface, and is the square of ten metres.

3. The LITRE, which is the unit of measures of capacity, and is the cube of a tenth part of the metre.

4. The STERE, which is the unit of measures of solidity, having the capacity of a cubic metre.

5. The GRAMME, which is the unit of measures of weight, and is the weight of that quantity of distilled water, at its maximum density, which fills the cube of the hundredth part of the metre.

Each unit has its decimal multiples and submultiples, that is, weights and measures ten times larger or ten times smaller than the principal unit. These multiples and submultiples are indicated by prefixes placed before the names of the several fundamental units. The prefixes denoting multiples are derived from the Greek language; and are *deka*, ten; *hecto*, hundred; *kilo*, thousand; and *myria*, ten thousand. Those denoting submultiples are taken from the Latin; and are, *deci*, tenth; *centi*, hundredth; and *milli*, thousandth.

The following table embraces all the weights and measures of the system:

Relative Value.	Length.	Surface.	Capacity.	Solidity.	Weight.
10,000	Myria-metre				
1,000	Kilo-metre		Kilo-litre		Kilo-gramme.
100	Hecto-metre	Hect-are	Hecto-litre		Hecto-gramme.
10	Deka-metre		Deka-litre	Deka-stere	Deka-gramme.
Unit.	**METRE.**	**ARE.**	**LITRE.**	**STERE.**	**GRAMME.**
.1	Deci-metre	Deci-are	Deci-litre	Deci-stere	Deci-gramme.
.01	Centi-metre	Centi-are	Centi-litre		Centi-gramme.
.001	Milli-metre		Milli-litre		Milli-gramme.

The denominations of solid measure beyond the first multiple and sub-multiple by *ten* are not in use. The term *stere* itself is in fact rarely employed, measures of solidity or volume being usually expressed in cubic denominations of the linear base. Of agrarian measures, the only derivatives of the unit in use are the hectare, the deciare, and the centiare.

VALUES OF UNITS.

UNIT OF LENGTH.

Myriametre	10,000	Metres.	
Kilometre	1,000	"	
Hectometre	100	"	
Decametre	10	"	
Metre	1	"	
Decimetre	0.1	"	or $\frac{1}{10}$ of a metre.
Centimetre	0.01	"	" $\frac{1}{100}$ " "
Millimetre	0.001	"	" $\frac{1}{1000}$ " "

The Metre is equal to 3.280899 feet nearly; or to 39.37079 inches.

The unit of Itinerary measure is the Kilometre, which is equal to 0.62138 miles.

UNIT OF SURFACE.

Hectare	100	Ares or	10,000	Square	Metres.	
Are	1	"	100	"	"	
Deciare	0.1	"	10	"	"	
Centiare	0.01	"	1	"	"	

The ARE is equal to 119.60332 square yards; the HECTARE, the Agrarian unit, to 2.47114 acres.

UNIT OF CAPACITY.

Hectolitre	= 100	Litres.	
Dekalitre	= 10	"	
LITRE	= 1	"	
Decilitre	= 0.1	"	or $\frac{1}{10}$ of a Litre.
Centilitre	= 0.01	"	" $\frac{1}{100}$ " "
Millilitre	= 0.001	"	" $\frac{1}{1000}$ " "

The LITRE is equal to 0.26418635 gallons, or 1.0567454 quarts, or 2.1134908 pints.

UNIT OF WEIGHT.

Kilogramme.....	1000	Grammes.	
Hectogramme.....	100	"	
Dekagramme.....	10	"	
GRAMME.....	1	"	
Decigramme	0.1	"	or $\frac{1}{10}$ of a gramme.
Centigramme.....	0.01	"	" $\frac{1}{100}$ " "
Milligramme.....	0.001	"	" $\frac{1}{1000}$ " "

The GRAMME is equal to 15.43234874 grains.*

The KILOGRAMME, which is the unit of commercial weight, is equal to 2.20462125 pounds avoirdupois.

---

* This is the Gramme as derived from the weight *in vacuo* of the platinum Kilogramme of the Archives, as determined by Prof. MILLER of London, in 1844, and adopted by the Standards-Department of the British Government. See APPENDIX B.

THE METRIC SYSTEM

OR

WEIGHTS AND MEASURES.

I.—*Recent Progress of Metrological Reform.*

INTRODUCTION.

GENTLEMEN OF THE CONVOCATION:

The sense of the right of property is an instinctive feeling, of which the existence is co-extensive with intelligence. We find abundant evidence of its presence in the lower animals as well as in ourselves. The dog, for instance, when he has satisfied his hunger, carefully stores up the superfluous bone of to-day, in prudent provision for the anticipated wants of the morrow. The beast of the forest bears his prey to the lair which he has appropriated to himself; and the birds defend with spirit the nests which their own labors have constructed. In the social animals, as the beaver, and the social insects, as the ant and the bee, we see the principle more broadly developed. In

these cases, the dwelling which the common toil has constructed or prepared, and the stores which the common industry has gathered, are the common property of all; and are apportioned for the benefit of individuals upon principles which we probably do not understand. But the lower animals, though they appropriate to themselves articles which seem desirable, and assert a right of property in the objects thus appropriated, never propose to relinquish one possession in consideration of an equivalent offered in the form of another. They have no notion of commerce or exchange even in its simplest form. The commercial idea makes its first appearance in man. It is present in every stage of human civilization. Its earliest practical illustration is in the form of barter, in which objects supposed to have value are exchanged one against the other; or a single one of a certain description for several of another. But as wealth increases, and as its forms become more diversified, the necessity of determining equivalents by quantity rather than by tale, becomes manifest; and out of this necessity springs the creation of conventional standards, by means of which quantities may be always and everywhere verified, and definite quantities be correctly ascertained. Hence have arisen the various systems of weight and measure which have prevailed among different peoples, some form of which has been found to accompany even the rudest civilization. Such systems having originated before anything like

intellectual culture existed, have been constructed without any thought of scientific method, and have owed their earliest form to accident or caprice. As social and political institutions have become more fully developed, legislation has stepped in from time to time to alter if not to improve these primitive systems; to change the value of their unit bases; or to modify the relations to these bases of the derivative denominations; until, at the present time, there is no reason to believe that there survives in any existing system of weights and measures a single value of any unit identical with one in use two thousand years ago; or a law of derivation connecting the different branches of the system, the weights and the measures of capacity, for instance, with the linear base, such as governed the same relations at a period so far remote in the past as the earlier ages of the christian era.

To change systems of weight and measure, and to change them by legislation, is therefore no new thing, first thought of in our day. It is a thing which has been going on ever since the birth of civilization. It is not in itself a good thing, or a desirable thing, or a thing we should engage in for its own sake; neither is it a desirable thing to pull down the dwelling in which we have long lived, even though it may be inconvenient. Time has, perhaps, reconciled us to the inconveniences; use has made us forgetful of their existence; or habit has possibly, for such is human nature, converted defects into merits in our eyes. But when

we do pull down the old home, and we often do, and Americans do so probably oftener than they ought, and in its place erect an edifice constructed on better principles, we find, in the increased comfort which follows, a justification of the proceeding, and a compensation for all the trouble and expense it has cost us.

There has grown up within our own century a branch of systematic inquiry, which in recent years has been prosecuted with a high degree of activity, under the name of "social science." This inquiry comprehends in its scope every problem interesting to human society, political, educational, moral, economical, commercial, statistical, and sanitary; its aim being not merely the enlargement of knowledge for its own sake, but the practical amelioration of the condition of man. In an investigation so comprehensive, the subject of weights, measures and coins, the instruments by means of which the values of all objects which make up the wealth of nations must be measured, and by means of which also the exchanges of commodities which constitute the world's commerce must be effected, could not escape attention. An earnest movement has accordingly been going on in our time which, during the past twenty years, has been pressed with especial urgency, having for its object to remove the impediments to freedom and facility of commercial intercourse between nations, and the obstacles to the intelligent understanding, on the part of individuals, of the material condition of the

world and the progress of contemporaneous history, which arise from the diversity and discordance of existing metrological systems. At a former meeting of this convocation, an ardent friend of the movement here spoken of, a gentleman who was at that time a member of our national legislature, addressed you on this subject, and recommended it earnestly to your favorable consideration. The result was disappointing. The movement failed to command from you the anticipated sympathy; and in approaching the same subject to-day, I feel how heavy is the task of one who attempts to plead before you a cause in which so able, so zealous, and so eloquent an advocate has failed.

There is something in the very fact that I venture to address you upon a subject which has occupied the attention of your learned body now for several years, which has been regularly referred to a committee of able and distinguished men selected from your number, which has been maturely considered and elaborately reported on by them, and has at length, after full opportunity for discussion and comparison of views, been finally disposed of by the adoption and publication of their report, which convicts me, in appearance at least, of presumption, and which is not likely to win me your favor in advance. It is, therefore, due to myself to say, that in asking your indulgence while I recall your attention for a few moments to a subject which has lost its novelty for you, I am acting under instructions from a body whose authority

I am not at liberty to disregard. On the first day of May last a resolution was adopted by the Board of Trustees of Columbia College, in the following words:

"*Resolved*, That the President be requested to attend the next meeting of the Convocation of the University of the State of New York, and to explain to that body how far the views of the Faculty of Columbia College, in respect to the Metric System of Weights and Measures, are in accordance with those set forth in the report of a Committee made to the Convocation on that subject in August last."

This resolution imposes upon me a duty which I have no choice but to fulfil. I trust, therefore, that I shall not be suspected of intending any disrespect to the Convocation if, in discharging it, I give expression to views considerably at variance with those which have received the sanction of this body.

ACTION OF THE TRUSTEES AND FACULTY OF COLUMBIA COLLEGE ON THE SUBJECT OF METROLOGICAL REFORM.

The interest of the Trustees of Columbia College in the Metric System of Weights and Measures, dates back to a period preceding my own connection with that institution. In the minutes of the Faculty of the college, I find it stated, under date of April 8, 1864, that a resolution calling the attention of the Faculty to the subject had been passed by the Trustees on the Monday preceding; and this resolution is recorded

under a date a little later, in the following words, viz.—

"*Resolved*, That in view of the important international movement in progress for the purpose of establishing a uniform system of Weights, Measures, and Coins for the civilized world, it be referred to the Faculty of the College to prepare and submit to this Board a memorial to the Congress of the United States, on behalf of the College, expressing its sense of the importance of the measure in question."

In compliance with the request of this resolution, a committee was appointed to draw up such a memorial, consisting of Professors McVickar, Anthon, Davies, Lieber, and Rood. Upon the thirteenth of May next following this appointment, the committee reported a memorial which was adopted by the Board of the College, and ordered to be signed by the President and laid before the Trustees.

In this memorial the metric unit of length is compared with the British (and American) unit; and the metric system of derivation, by which the measures of surface, capacity, solidity, and weight, are deduced from the unit of length, is compared with the confused system or lack of system which unfortunately pervades the metrology of the English speaking nations; and on both these points the opinion of the Faculty of Columbia College is expressed, with an emphasis which argues deep conviction, in favor of the former. The

memorial goes further, and advocates certain views in regard to the unification of the coinage of the world, in which I should not be able fully to concur, but to which I design to give no present attention, since the coinage question is one which will probably be independently settled; though when it is settled it will doubtless be settled by making the weights of all coins metrical.*

In the minutes of the Trustees of the college, I find it recorded that the document here spoken of was read before that body on the 18th of May, 1864, and that an order was afterwards taken directing that it should be forwarded to the Speaker of the House of Representatives at Washington, with a request that he should lay it before the national legislature. This memorial is spread at length upon the minutes both of the Faculty and of the Trustees. Along with it appears, in the latter, an independent memorial expressing similar sentiments, which was adopted by the Trustees

* The question of the unification of coins has been the subject of several international conferences and of much diplomatic negotiation. A definite proposition regarding it was addressed to foreign governments, in 1870, by the Government of the United States, through its ministers resident abroad, which proposition may be regarded as still pending. This consideration alone would suggest the propriety of refraining from the discussion in this place of the various projects for such unification, which have been heretofore proposed. The question, however, is complicated by considerations of great gravity, which affect but slightly the simpler one of the unification of systems of weight and measure; and which render it expedient, if not indispensable, that the two questions should be kept separate. See APPENDIX A.

in their own behalf, and forwarded to Congress by their order at the same time.

With all this history I had nothing to do. The whole transaction had been completed before I became a member either of the Faculty or of the Board of Trustees of Columbia College. I have recounted the particulars in evidence that Columbia College had taken her position on this question long ago. The duty imposed upon me is to state to you some of the reasons which have led her to assume this attitude.

And here I wish to be understood as not intending to assert that, among the members of the two bodies whom I, in a certain sense, represent here, there are not individuals who dissent from the views to which the majority have committed themselves. Among the Trustees, indeed, I know of none such; but your own records show that there is at least one distinguished dissentient among the Faculty. If there are others, they, as well as myself, are members of this convocation; and they may, and perhaps will, speak for themselves. I am not aware that there are any, but my impression may be mistaken.

THE PREVALENCE OF A PARTICULAR SYSTEM LESS IMPORTANT THAN THE ADOPTION OF A COMMON SYSTEM.

To proceed now to the matter in hand, it is, in the first place, a fact particularly noteworthy, that the Trustees of Columbia College, in their resolution of

April, 1864, did not mention the metric system in so many words, nor propose to memorialize Congress in favor of any particular system of weights and measures designated by name. What they asked was that the college should express its sense of the importance of the creation of a *uniform* system of weights and measures for the use of the civilized world. If they have been led to believe, as I think they have, that such a uniform system can be reached in no other way than through the ultimate adoption of the metric system; and that whatever may be the differences of opinion as to this matter just here and now, such a result most inevitably will be reached in this way sooner or later; it is impossible that they can regard without concern the exertion of any influence which may serve sensibly to retard an event deemed by them so desirable, and which however retarded is, in their opinion, sure to come at last.

But still the question raised by them, and the question first in order before us now, is not, whether it is expedient that we should forthwith adopt the metric system; it is rather, whether it is worth while to try to secure a common system; because, if this is not so, there is nothing left to talk about. Nor yet, supposing that this first question is settled affirmatively, and we agree that a common system of weights and measures would be worth having if we could get it, can we make the question of the metric system even the second question in order; for the second question

should be, what are the efforts, of those which we are able and willing to make to secure the desired object, in attempting which we may be encouraged by the hope of success; and what are those which we may as well take warning in the outset to avoid, as certain inevitably to fail.

THE MAIN OBSTACLE TO METROLOGICAL REFORM CONSISTS IN THE INCOMMENSURABILITY OF UNIT BASES.

Now, in looking at the different metrological systems at present in use in the civilized world—and the number is very encouragingly smaller at present than it was even twenty years ago—we shall see that the great obstacle in the way of the practical unification of systems is not the mere fact of difference in the absolute magnitude of the standard units whether of weight or of length or of surface or of capacity; nor the mere fact of difference in the names by which we distinguish these units and their multiples or subdivisions; nor the mere fact of difference in the arithmetical law by which the several denominations of weight or measure are related to each other; nor yet the greater or less degree of exactness with which the base of any system may conform to any dimension in nature variable or invariable; though these are matters concerning which a great deal of breath is wasted in the discussions which go on about the metric system; the difficulty which stands out so prominently as to dwarf all the rest to insignificance, is the fact that the standard units of

these several systems are practically incommensurable. I say *practically* incommensurable—I am not using terms with strict scientific severity—but the difficulty is as serious as if the incommensurability were actual and absolute.

To illustrate what I mean: the Austrian foot measure, for instance, exceeds our own by 361 ten-thousandth parts; or, expressed in inches, it is equal to 12 British or American inches and 4332-10000ths of an inch. We might reverse the mode of presentation, and say that the American foot is 0.96516 of an Austrian foot, or 11.5819 Austrian inches. The fractions here given do not express the exact relation. We may run the decimals on for half a mile without reaching the end; but they go far enough for the purpose of my illustration.

To transform, therefore, a value expressed in one of these measures into an equivalent value expressed in the other, is an operation laborious and irksome. But the arithmetical disadvantage is by no means the whole, or even the greater part, of the evil which this state of things produces. A much more grave consideration is the fact that it interposes an effectual bar to the intelligent interchange of thought. It renders it impossible for an American to converse understandingly with an Austrian on any subject involving quantities of any description. It makes it impossible for an American to derive instruction from an Austrian book or magazine or journal where quantities are

mentioned; or an Austrian from an American. This is an enormous evil, and as it exists not in this quarter only, but everywhere, the world has crying need of its removal. It is the evil of which, first and chiefest of all, the advocates of metrological reform desire to be rid. And yet, unless I greatly misunderstand the purport of much of the reasoning I hear going on upon this subject, the very fact that this abominable evil exists, the very fact that there is something to be got rid of, something that we want to be rid of and something which we ought to be rid of, is made an argument why we should not try to be rid of it at all. If there are any to whom this argument is satisfactory, with them of course the case is closed, and upon such nothing that I can say will produce any impression. There are some, probably, not of this class, and they may be disposed to consider with me what means there are by which we may be relieved of this artificial obstruction to intelligent communication with other peoples.

METHODS POSSIBLE OF OVERCOMING THE OBSTACLE.

Three methods present themselves. Continuing the illustration furnished by the example just presented, they are these: We may adopt the Austrian unit; Austria may adopt ours; or both nations may adopt a third, incommensurable with either. Any one of these expedients will reconcile us with each other; that one will be chosen, if any, which, besides doing

this, will do most to promote the grander object of an universal accord among nations.

Now, if we go over to Austria in this matter, we lose more than we gain; and in speaking of loss and gain here, I mean loss and gain as it respects our international relations, and not as it respects our internal or domestic affairs; (I am setting aside altogether, therefore, that inconvenience to ourselves at home, which would exist temporarily in consequence of the incommensurability of the new unit with the old—an inconvenience on which your able reporter has so feelingly dwelt as likely to result from our giving up the foot for the metre)—we lose then I say, more than we gain by this concession, because we fall out of harmony with the great British Empire for the sake of securing harmony with a people who occupy, as Mr. Webster more forcibly than politely remarked, only a small patch of the earth's surface, compared with our vast domain. On the other hand, if Austria yields the point, she will fall into harmony, it is true, with us and with Great Britain, nations however from whom she is geographically separated very widely; but this advantage will be gained at the expense of discord with the several peoples who lie between her and the British Islands; all of whom have embraced the metric system, or adopted metric values in their own. If, however, thirdly, both of us adopt the metre, America will not only be in accord with Austria, but with the greater part of continental

Europe at the same time; and as Great Britain has given decisive indications of a disposition to become metric also, the probability is that, soon, the whole civilized world, unless Russia and the Scandinavian peoples continue to be exceptions, will have but a single system of weights and measures.

SIMPLICITY OF THE PROBLEM OF UNIFICATION WHEN UNIT BASES ARE COMMENSURABLE.

Now if this difference between us and Austria had not been *such* a difference; if the unit, for instance, of Austria, had been we will say a cubit, and such a cubit (for there have been many of them) as to be exactly equal to eighteen British inches; the evil of incommensurability would not exist and the question of unification would simplify itself materially. We might both of us agree to adopt a measure of six inches as our common unit; and this we might call a span, abandoning both the cubit and the foot. There would be some, no doubt, who would lament over the loss of the "short and sharp Saxon word, foot," and would find no sufficient comfort even in "span," which though Saxon and short is not so sharp; but I think that if a change of this simple description, affecting only names and modes of division and not actual values at all, would bring us into harmony with any great people, and still more if it would bring us into harmony with all the world, we should do it notwithstanding. This illustrates the

immense difference as it respects facility of solution which the problem of metrological unification would present, if the unit bases of the existing national systems were commensurable with each other, as compared with what it is now.

With the great empire of Russia, we have, indeed, precisely such a point of contact in our two national systems of length measure, as that which I have just been imagining. It is matter of familiar history, that in the year 1698, the singularly enterprising and energetic emperor, PETER *the Great*, passed, incognito, in the train of one of his own embassies, first into Holland, where he engaged himself as an operative ship-carpenter, and labored for months with remarkable assiduity; and secondly, in the following year, into England, where he became finally master of that important branch of constructive art; and where subsequently, having made himself known to the then reigning King, WILLIAM III., he received from that monarch every honor due to his exalted station. Returning to his own country, he took with him a number of British ship-builders and other artificers, whom he paid with liberality and employed in the navy yards which he immediately proceeded to found. It was probably a consequence of his own industrial education in England, and of the British predilections of the advisers and practical assistants whom he took home with him to carry out his plans, that he was induced to modify the length of the *sagene*, the standard length

unit of the empire, so as to make it commensurable with the British foot. Since early in the eighteenth century, therefore, the length of the legal standard unit of Russia has been seven feet, subdivided into three archines of twenty-eight inches each; the archine being the unit of common life, just as in England, the yard is the legal, and the foot the practical, standard. This state of things admitted of the introduction between ourselves and Russia of a common unit of four inches in length, which would have been just the seventh part of an archine and the third part of a foot. But within the last forty years a simpler solution has been found, the Russian government having introduced a subsidiary unit, one-seventh of a sagene in length, which is called by a name approaching as nearly to the English word foot as the vocal organs of the people will allow.

It is unfortunate that a reform so well begun was prosecuted no further. This is the only particular in which the Russian metrological system has anything in common with ours, or with any other existing. And, from a careful examination of all the systems of weights and measures established by law, and at present in use among civilized peoples, I have been unable, except in this single instance, to discover between any two of them, any feature of commensurability, whether as it respects weights or measures of length or surface or volume, which has not been introduced by legislation since this century began.

RECENT ENCOURAGING PROGRESS OF METROLOGICAL REFORM.

Such legislation has, however, within the period here indicated, done so much toward removing this chief of all obstacles to the attainment of a common system, as greatly to encourage the friends of metrological reform in the hope of an ultimate and complete attainment of the object in which they are so deeply interested. It is worth remarking, furthermore, that every such change has thus far consisted in replacing the values of the weights and measures in common use by other values adopted from the metric system. I will enumerate further on the most important of these changes; pausing here only to present a single example to show how, in some instances, the great evil of incommensurability has been got rid of without the adoption of the metric system in all its details.

In the republic of Switzerland, previously to the year 1851, there prevailed a considerable diversity of systems of weight and measure in the different cantons. The most important may be said to have been those of Berne, Zurich, Basel and Lucerne—I will confine myself to the first two named. In Berne, the *fuss* (unit of length) was 11.546 inches; in Zurich, it was 11.812 inches. In Berne, the *pfund* (unit of weight) was 18.642 ounces avoirdupois; in Zurich, it was 18.347 ounces. In Berne, the *maas* (measure of liquid capacity) was 1.766 quarts; in Zurich, it was 1.918

quarts. The measures of dry capacity were very various; but those which are most easily comparable were the *maas*, in Berne, which was 0.3876 of a bushel, equal to 1.550 pecks; and the *viertel*, in Zurich, which was 0.5826 of a bushel, or 2.330 pecks. Zurich had, in fact, four different viertels for different substances; the measure given above was for wheat. By a law passed the 23d of March, 1851, it was decreed that, after the 31st of December, 1856, the legal unit of length throughout the republic should be the *pied* (foot), having the length of exactly thirty centimetres; and that (abandoning the old duodecimal subdivision) this should be decimally divided to tenths, hundredths, and thousandths. Multiples of the unit allowed were the *brache*, 2 feet; the *aune*, 4 feet: the *toise*, 6 feet; the *perche*, 10 feet; and the *lieue*, 16,000. For the pfund was substituted the *livre* of 500 grammes; and for subdivision it was left optional to use the binary system of half-pound, quarter-pound, and so on, or to employ the decimal. For dry capacity, the measure established was the *quarteron*, equal to 15 litres; and for liquid capacity, the *pot*, equal to one and a half litres. For the last fifteen years, therefore, the weights and measures of Switzerland have been commensurable with those of the neighbors with whom she is in most frequent intercourse, and who have all of them, more or less completely, adopted the metric system.

DISCORDANT LAWS REGULATING DERIVATIVE DENOMINATIONS INCREASE THE DIFFICULTY OF TRANSFORMING VALUES.

But though the incommensurability of the unit bases is the principal source of difficulty in effecting transformations of value from one metrological system to another, the law of derivation of the other denominations from these bases is not a matter of indifference as it respects this operation. This, again, can be illustrated by an example which the commensurability of the Russian standard unit of length with our own enables us to derive from the itinerary measure in common use in the Russian empire. This itinerary unit is the *viersta*, anglicized verst, which is equal to 500 sagenes. Now there is no difficulty in converting versts into British feet, since (the sagene containing seven feet) 500 sagenes are 3,500 British feet, or the half of 7,000 British feet; so that we only have to multiply the versts by seven, annex three zeros, and take half the result. But if we wish to transform a distance expressed in versts into miles—a mile being the unit of our own itinerary measure—the process is not so simple. There are 5,280 feet in a mile, and if, in order to avoid this troublesome divisor, we attempt a reduction through the intermediate denominations, we encounter such relations as $5\frac{1}{2}$ yards, or $16\frac{1}{2}$ feet, making a rod, which are more troublesome still. Now

if, instead of the present totally indefensible series of relations between our higher and lower denominations of length, we had something a little more sensible, or if not sensible, at least not worse than the Russian (for the Russian, with its ratio of seven to one, is only a little less bad than ours), the problem before us would admit of a solution comparatively simple. Suppose, for example, that a mile were made, as it might be, without harm to anybody, a round five thousand feet. It is true that "the old familiar mile of 1,760 paces," which your reporter seems to cherish so fondly, "would be gone; and," as he correctly remarks, "the distance from Albany to New York—one hundred and forty-five miles—would be known to us" as something quite different, say something like one hundred and fifty-three sensible miles. In this case the verst would be 3,500-5000, or seven-tenths of a mile, and the transformation would be effected by the use of a very small number of figures. It would not, perhaps, be worth while to adopt the new value of the mile here suggested, for the sake of being able merely to convert miles to versts, or versts to miles—a thing we have to do too seldom to make it a matter of much interest to us; but it *would* be quite worth while to make it for the sake of facilitating the thousand other calculations which we are continually called upon to make, involving reductions between the higher denominations of length and the lower.

ABSURDITY OF THE NUMERICAL RELATIONS BETWEEN THE DIFFERENT DENOMINATIONS OF MEASURE AND WEIGHT IN THE UNITED STATES.

Whether we ever adopt a new linear base for our metrological system or not, every consideration both of logic and of convenience demands that we should reform the absurd numerical relations in which our different denominations, especially of length, surface and capacity, stand to each other. Mention has been made of the mile, the rod, the yard, and the foot. Along with these we may take also the chain of sixty-six feet, divided into links of which each one is seven inches and ninety-two-hundredths, while itself is the eightieth part of a mile.

As to surface, our square yard is nine square feet; our square rod is $30\frac{1}{4}$ square yards, or $272\frac{1}{4}$ square feet; and the acre, our agrarian unit, is 160 square rods, or 4,840 square yards, or 43,560 square feet. It would be difficult for human ingenuity to contrive anything more inconvenient or less rational than this.

As to capacity, whether liquid or dry, though the relations of the several denominations to each other are tolerably simple, yet their relations to the standard of length, which is, or ought to be, the fundamental base of the system, are as abnormal as it is possible to make them. Our gallon is 231 cubic inches = 0.13368 of a cubic foot; and our bushel is 2,150.42 cubic inches = 1.244456 cubic feet. And our unit of weight has no

relation whatever expressible in simple numbers which the mind can grasp, to our measures of capacity or of length ; for while it is customary to say that a cubic foot of water weighs one thousand ounces, the relation established forty years ago by our bureau of weights and measures, under authority of law, makes the gallon measure of distilled water at the temperature of maximum density, viz., 39°.8 F., and at thirty inches of the barometer, to weigh 58,372.1754 grains, or 8.3388822 commercial or avoirdupois pounds ; and requires also that the standard or Winchester bushel of 2,150.42 cubic inches shall hold, under the same circumstances, 543,391.89 grains, or 77.627413 avoirdupois pounds* ; from either or both of which determinations it appears that the weight of a cubic foot of water, at maximum density, is only 998.0667 ounces, instead of 1,000 ounces ; while, if we take the water at the ordinary temperature of the atmosphere, say 62° F., as prescribed by the British statute on the subject, the cubic foot weighs but 997.172 ounces.

Here are irregularities and imperfections, to the correction of which it would be well if we would address ourselves, in our own immediate interest and that of our people at home merely, and without reference to our relations with other peoples. Exact calculations, for instance, in which weights are to be deduced from volumes, or volumes from weights, are effected under our system only at the expense of much weary labor,

* The determination of the bushel, however, by weight, allows it only 2150.4 cubic inches. See APPENDIX B, *Note* 1.

of which the necessity is artificially laid upon us by this tyranny to which we are born. For rude calculations we call, indeed, the cubic foot of standard water one thousand ounces, or sixty-two and a half pounds; but for any delicate determination, we must take the cubic foot at 436,654.1952 grains, and the cubic inch at 252.6934 grains, numbers which, at whatever inconvenience, the man of science finds himself continually obliged to employ in multiplication and division, to the great waste of his time and expense of his strength.*

IS IT POSSIBLE TO SECURE GENERAL COMMENSURABILITY OF UNIT BASES?

Now before directly considering the special question whether the metric system of weights and measures ought to be adopted in this country, it is proper to consider, and it seems to me to be a duty to consider, whether it is possible for us to contribute anything to the important object of bringing the bases of the metrological systems of the world into relations of commensurability. If these bases can be made commensurable, we shall have accomplished something almost as important as to have established absolute identity; and, indeed, under these circumstances, identity, it may easily be believed, will not be slow to follow. Who can doubt, for instance, that Switzerland, having adopted values for her units which are in extremely simple relations to the metric units, will sooner or later

* See APPENDIX B, for an examination of the probable accuracy of these values.

adopt the metric units themselves. It is what the states of Northern Germany recently resolved to do after an experience very similar. These several states had all, previously to the formation of the Zollverein, their independent systems of weights and measures. When that treaty was entered into, the importance of a common system for custom-house purposes was promptly perceived; and hence a Zollverein pound was adopted, having the weight of five hundred grammes. Several of these states, among them Prussia, Baden, Hesse-Darmstadt and Wurtemberg, found it expedient at a later period to adopt this weight for their domestic as well as for their external commerce. And after the Austro-Prussian war of 1866, and the formation of a closer union between the states north of the Maine under the name of the North German Confederation, the desirability of a common metrological system for all the members of the confederation seemed so great, that a law was finally passed by the Reichstag, which was publicly proclaimed by the king in August, 1868, by which the metric system is adopted in full, and made the legal system for North Germany from and after January 1, 1872. As the states of southern Germany were no less advanced than those of northern, in the measures they had taken previously to their absorption into the empire, for the assimilation of their weights and measures to those of the metric system, there can be no doubt that the law of 1868, just mentioned, will be extended over them also.

Thus it appears that when different metrological systems approach each other so far as to become commensurable in their fundamental units, there is a drift towards identity which becomes at length irresistible.

THE WORLD WILL HAVE A COMMON SYSTEM OF WEIGHTS AND MEASURES; THE CHOICE MUST LIE BETWEEN OUR OWN AND THE METRIC.

Are we willing to do anything to bring our own system into relations of commensurability with those of the rest of the world? If so, the question second in order comes up, what efforts are there in our power to make, which are likely to advance the object, and what are likely to be fruitless? It may be well to state, in the very outset, so as to bring the really vital question directly before us, that except the metric system and that which we use ourselves, no other existing and no other likely to exist, can be advocated as having the least claim to become the system of the world. One of these, therefore, must sooner or later prevail; for no man not totally regardless of the history of the past, and not absolutely blind to what is taking place under his own eyes in the present, can possibly pretend to believe that the world is to be forever without a uniform system of weights and measures. At the universal exposition of 1867, in Paris, thirteen measures of length from different countries were exhibited under the name of foot, or its equivalent; but among these there were only eight values essentially

different; and two of these were metric. Yet after giving some attention to this subject without pretending to exhaust it, I have found more than one hundred foot-measures, each differing more or less from all the rest in value, which have been in use at one time or another at one part or another of Europe. Similar remarks might be made of the units of weight and capacity. There has therefore been large progress made toward uniformity, and the most important steps and the most significant steps are those which have been taken within our own century. We cannot suppose that this progress is going to be arrested at the point which it has now reached. Of the two systems therefore just now indicated as the systems between which the world must choose, unless in regard to this matter it shall henceforth stand still forever, one or the other must sooner or later prevail. Which shall it be? Which is it likely to be?

ABRUPTNESS OF THE INTRODUCTION OF THE METRIC SYSTEM INTO FRANCE.

At the close of the last century the metric system was thrust upon France, under circumstances of disadvantage and with an imperfect success which Mr. ADAMS has very eloquently described in his able report of 1821, which you have caused to be reprinted. Though the commission by which the system was matured was as far international as it was possible in the then existing political and military condition of

Europe to make it, representatives being present not only from France, but also from the Netherlands, Denmark, Sweden, Spain, Switzerland, Sardinia, Rome, and the Cisalpine and Ligurian Republics; yet no government except the French spontaneously adopted, and endeavored to apply in practice, the results of their labors. The conquests of the first empire carried the system forcibly into the Low Countries, into portions of Germany, into Italy and into the Iberian peninsula; but the difficulties which it met with there were in general greater than at home; not only because the manner of its introduction did violence to men's established habits of thought, but because its existence was a badge of subjugation and a perpetual reminder of the national humiliation of those who were compelled to use it. These all with one accord, therefore, took advantage of the downfall of the empire, to throw it promptly off. Nor even in France, presented as it was to the people without any adequate education as to its characteristic features, or any sufficient allowance of time to permit them to become familiar with its details, was it established without a struggle against inveterate habits and rooted prejudices continued through more than a quarter of a century.

SUBSIDENCE OF OPPOSITION TO THE SYSTEM.

Long before the termination of this struggle, however, the aversion to the system in the countries foreign to France to which it had been carried during

the empire, began sensibly to subside, and in the Netherlands whose intimate relations with France had caused it there to take a deeper root than elsewhere, it was actually re-established as early as 1817. It was re-established, that is to say, in all particulars except the nomenclature; but while the metric units and the metric decimal relations were adopted, the ancient names of weights and measures were retained. Belgium, however, which was for a time a part of France, employed the nomenclature also; the old names were preserved in Holland till April, 1869, when they were at length abandoned.

The condition of things, therefore, at the time when Mr. ADAMS wrote may be thus described. A quarter of a century had passed and yet the system was not yet firmly established in its own home; it had been rejected generally by the neighboring peoples who had tried it; and its chances of success in the eyes of the disinterested spectators of the experiment appeared, as may be gathered from Mr. ADAMS'S own report, to be as nearly as possible at zero. Since that period just one half a century has passed, and the aspect of things has bravely changed. One third part only of this period sufficed for the subsidence of all the imputed disaffection of France; and in the Netherlands, as we have seen, this disaffection, if it was ever strong, died out much earlier. From the year 1837 onward, the people of those two countries have not only been reconciled to the system, but have been warmly attached to it. The neigh-

boring peoples upon whom it had been early imposed by force, and who had indignantly thrown it off, have all voluntarily re-adopted it. That early attempt to coerce them into its acceptance, while it roused every instinct of their natures to resistance, had at least the effect to educate them to a knowledge of what it was. And the acquaintance which they thus formed of its merits, produced, when passion had subsided, its natural result in the re-establishment of the system by their own free choice.

ACCEPTANCE OF THE SYSTEM BY EUROPEAN STATES SUCCESSIVELY.

From information obtained at the universal exposition of 1867, where a special pavilion was set apart for the display of the standards of weight, measure, and money of all nations, officially authenticated, I am able to state some particulars as to the progress of this great movement toward metrological uniformity. First in the order of time after France, Holland, and Belgium, came the kingdom of Greece, which adopted the metric system of weights and measures as early as September, 1836. A little earlier than this (March, 1833) had been formed the customs union or Zollverein, which I have already mentioned, among the German States, embracing, originally, Prussia, Saxony, Bavaria, Wurtemberg, and Hesse Cassel; but ultimately including all the states of the German Bund except Austria, Lichtenstein, Holstein, the two

Mecklenburgs, Hamburg, Lubeck, and Bremen. This as established for the purpose of doing away with he serious obstruction to commerce interposed by the existence of numerous and neighboring custom-house frontiers ; but in order that it might not create as much trouble as it removed, it adopted, as I have mentioned already, a common unit of weight, having the metrical value of five hundred grammes, or half a kilogramme. This, which first came into use on the first of January, 1840, was found so convenient that it subsequently became the national as well as the international pound in several of the principal states and many of the smaller ; as, for instance, in Prussia, Wurtemberg, Baden, and Hesse Darmstadt.

In some, as in Baden and Hesse Darmstadt, metrical values were also given to the unit of length, which was still called the *fuss*, though the old *fuss* was abolished ; and the duodecimal subdivision was at the same time abandoned. Others of these states which still retained the values of the fuss to which they were accustomed, perceiving the great superiority, in respect to convenience, of the decimal over the duodecimal ratio, also abolished the inch, and divided the foot into tenths and hundredths. Among these may be named Bavaria, Prussia, and Wurtemberg. In Italy, a law of 1845 brought the metric system fully into force in the kingdom of Sardinia from the first of January, 1850. It was established in the Pontifical States soon after ; and, by a law passed July 28, 1861, was ex-

tended over the entire Italian peninsula, and also over Sicily from and after the first of January, 1863.

Very shortly after the revolutionary excitements of 1848, the empire of Austria, by treaty with Prussia, became connected with the Zollverein, and introduced the metrical weights and measures of that union into all the custom-houses of her extended frontier; nor has the course of events, military or political, of recent years, produced in that empire any change in this respect. The action of the North German Confederation, by which the metric system in full became the system of all the Northern states, for domestic as well as for external uses, took place in 1868, as has been already mentioned. In the mean time, other states, not connected with the Zollverein, began to fall in with the drift now becoming so general. In 1851 took place the legislation in Switzerland above described, which gave to that confederation a metric system of weights and measures after 1856.

In 1852, Denmark adopted the metric pound of 500 grammes, decimally divided. In 1855, Sweden, without changing the values of her standard units, introduced partially the principle of decimal derivation for the inferior and superior denominations; and this, by more recent enactments, reduced in 1865 to a single comprehensive law, she has extended through her whole system. In the following year, 1866, Norway, in regard to this matter, followed the example of her sister kingdom. In Spain and her colonies, the metric

system was established by law in 1859, the names of the units having been partially transformed to bring them into harmony with the language—the metre being called the *metro*, the litre the *litro*, etc. In 1864, the metric system was established in Portugal ; and in the same year a law was passed in the principality of Roumania prescribing the use of the system in that principality from and after the first day of January, 1865. Even Turkey has recently made a beginning toward bringing her system into harmony with that which is now so rapidly becoming the system of all continental Europe, by giving to her unit of length, the archine, the value of seventy-five centimetres, or three-quarters of a metre. In Great Britain, by an act of Parliament passed in 1864, the metric system is legalized, though it has not been made compulsory. In 1868, another act, making the metric the exclusive system for Great Britain, passed its second reading in the House of Commons, having thus reached a stage of legislation where the final passage of a bill is commonly regarded as assured, when it was withdrawn by its originators, as yet premature ; but the fact of this remarkable success is a signal evidence of the state of opinion among the enlightened classes of the British people,* and a plain premonition of what Great Britain will sooner or later do.

* For a more full account of British legislation in regard to the Metric System, see APPENDIX C.

LEGISLATION IN REGARD TO THE SYSTEM ON THE AMERICAN CONTINENT.

In our own country the use of the metric system in business transactions was legalized by act of Congress of July 27, 1866. Another act, which was passed almost simultaneously with this, provided that postages should be charged in accordance with a scale of metric weights; a letter weighing fifteen grammes or less to be chargeable with but one rate of postage. This provision of law, which was practically in favor of the people who use the post-office to a sensible degree, fifteen grammes exceeding the previously legal postage weight by nearly thirteen grains, or about one-seventeenth part, was, as I am informed, by the effect of a statute passed the following day, quite unintentionally repealed.* This second act was designed to regulate postage with foreign countries, and it provided that, for postal purposes, one half ounce avoirdupois should be deemed and taken to be the equivalent of fifteen grammes. The department has applied this provision to the act of the preceding day; so that we have Congress going through with the solemn farce of enacting that the limiting weight of a single letter shall be fifteen grammes, but then that these fifteen grammes shall be deemed and taken to be only half an ounce.

Undoubtedly the stationery on which these provisions of law were written must be deemed and taken to be a dead loss to the nation. But could anything more forcibly illustrate the liability to error and con-

* See further as to this, p. 233, Supplement.

fusion arising out of diversity of systems of weight and measure, than this example wherein we see even our highest legislative body, when entangled in the maze, incapable of making laws to express its own intentions?

In South America, the metric system has been adopted by Brazil (to take full effect in 1873), in the Argentine Republic (1863), in Uruguay (1862), in Peru (1863), in Chili (1848), in Ecuador (1856), and in New Granada (1863). In North America, it was established by law in Mexico in 1856. According to the best authorities I have been able to find, the total population of Europe approaches 298,000,000, of whom about 135,000,000 have already accepted the metric system in all its details, or have given to all the standard units of their own systems, metric values. Add to these 25,000,000 more in Mexico and South America, and we have a total of 160,000,000 of civilized people in Christian lands who are irrevocably committed to the metric system; while a considerable proportion of the rest have made progress toward this system by adopting metric values in part, like Denmark, and Austria, and Turkey; or by adopting the decimal law of derivation without as yet the metric values, like Sweden: while there are seventy millions more, the people of the British Islands and of the United States, who have made the use of the denominations of the system lawful in all business transactions within their territory.*

* For more exact statistics on this subject, see APPENDIX D.

PAST METROLOGICAL REFORMS NOT ATTRIBUTABLE TO POLITICAL CAUSES, BUT TO THE FORCE OF PUBLIC OPINION.

All this has been accomplished by the pressure of public opinion; it has been distinctively a movement of the people and not of governments; it is a social rather than a political phenomenon. When the metric system was first introduced into France, the pressure came from above, and was resisted by those upon whom it pressed. The people did not understand the system and they did not want it. In the discussions which we hear going on about us concerning it at the present time, the opponents of the system seem constantly to assume that the same plan is to be pursued to-day; and that there exists somewhere an insidious design to force the system upon peoples whether they like it or not. That, I take it, is not the spirit of the modern propaganda. Neither the British people nor the American people are expected to accept this system unless they think it best; but the presumption of some of us is that they will sooner or later think it best.

CAUSES OF THE INDIFFERENCE TO METROLOGICAL REFORM IN THE UNITED STATES.

But why, it may with justice be inquired, are our people so far behind those of the continent of Europe in appreciating the value of the metric system? This is to

be accounted for by the same reasons which make them comparatively indifferent to the existence of *any* international system of weights and measures. In a large country like ours, widely separated from the rest of the world, the inconvenience of metrological diversity is immediately and personally felt by the individual citizen only on rare occasions; when, for example, he travels in a foreign country, or when in his own he meets a foreigner raw to our institutions, or when he attempts to obtain some exact information from the publications of other countries; while the disadvantages to which it daily subjects him operate in a manner so indirect, and are mixed up, too, with so many other matters, that he fails to connect them with their causes. We can easily understand the state of things which would exist if we had no public standard of weights and measures at all; and if every tradesman made his own system, and sold his customer, say, so much for so much. This plan is illustrated in Diedrich Knickerbocker's account of the dealings of the early settlers of the Nieuw Nederlandts with the Indians—"every Dutchman's hand weighed a pound, and every Dutchman's foot weighed two pounds." The inconveniences and uncertainty of trade would be only a little less if, instead of having as many systems as there are tradesmen, we should have as many as there are villages. If, for instance, while a man can get on very comfortably among his immediate neighbors, he finds himself, on driving four or five miles, entirely at sea

on the subject of quantities, he will be scarcely able to prosecute any business of magnitude without an amount of trouble and confusion quite intolerable. Enlarge the communities within which common systems prevail, and separate them more widely from those which employ different systems, and the evils which, in the original supposition, embarrassed individuals, now affect the transactions which take place between these communities. Operations are larger, and they are mainly conducted by a particular class; but the misapprehensions, the delays, and the increased expense attendant on these operations, are charged, like the customs duties, upon the whole community, without their being clearly conscious of the fact. Our custom-houses, and our great importing houses, are compelled, by the diversity of weights, measures, and moneys with which they have to deal, to employ an immense staff of computers, whose sole business is to effect transformations of values upon the invoices of the commodities which pass through their hands; and the salaries of all these employees are undoubtedly paid by the consumers of the commodities.

Now, on the continent of Europe, where, in the central part at least, the territories of independent states have heretofore been small, while the population is dense, the evil of a multiplicity of systems of weight and measure, and of custom-house lines occurring every ten, twenty, or thirty miles, has been felt as, of course, we can never feel it; and, therefore, there is

nothing surprising in the fact that the people of those states have perceived the need of a common system to be pressing, when we were not thinking of the matter at all. Nor is it any more surprising that, in looking about for a common system, and finding the metric system to be an existing system, and a good system, and, above all, an available system, and the only one apparently available for the purpose, they should have seized upon it, and legalized it, and made it permanent, without too anxiously concerning themselves with the questions whether the metre would not have been better if it had been a little longer or a little shorter, or if it had represented something different from what it does represent, or whether, in fact, it does, after all, really represent any thing at all.

UNIVERSAL PREVALENCE OF THE SYSTEM IN EUROPE INEVITABLE.

Considering, therefore, the nature of the causes which have induced one hundred and thirty-five millions of the people of Europe to adopt the metric system; and considering furthermore that in Denmark, Sweden, Norway, Austria, and Turkey, we have fifty-five millions more who have shown, by their legislation, their appreciation of the merits of this system, or of the principles on which it is founded; it may, I think, be safely said that the universal extension of this system over the continent of Europe is only a question of time.

THE SCIENCE OF THE WORLD FAVORS THE METRIC SYSTEM.

Besides the causes which I have mentioned, out of which the important changes I have just described have grown, it is to be remembered that there are other influences of a very powerful description actively at work to recommend the metric system to the favorable consideration of the peoples which have not yet received it. The principal of these peoples are the English speaking nations, and the inhabitants of the Russian empire. Now, for a very long period, it has been true that the great body of the scientific men of our own country, of Great Britain, and of Russia, have been thoroughly impressed with the value of the metric system; and many of them have been constantly in the habit of using it. That there has been here and there a dissenter may be admitted. Here, as elsewhere, *exceptio probat regulam.* But a dissenter who, like Sir JOHN HERSCHEL, holds that the system is good, but that the base ought to have been a ten-millionth part of something else, rather than of a quadrant of the meridian, is not much of a dissenter after all; and one who, like Prof. PIAZZI SMYTH, bases his metrological theories on religious grounds, and prefers the pyramid-inch as his standard, as a matter of conscience, is not likely to concentrate around him a very powerful party of opposition.

Scientific associations in the countries just named have memorialized their governments in favor of the

metric system. The British Association for the Advancement of Science has done this repeatedly, and the Imperial Academy of Sciences of St. Petersburg has done it likewise. In the year 1866, the National Academy of Sciences of the United States, on the report of a committee having Prof. HENRY, of the Smithsonian Institution, at its head, (a committee which had had for two years the subject in its charge), addressed a memorial to the Congress of the United States, expressing the sense of the Academy as to the importance of establishing an international system of weights and measures, and recommending the metric system as the best existing.

The scientific journals, throughout the world, give evidence of the growing practice of scientific investigators of using metric values in their experiments, in their calculations, and in their writings. This began in Germany very early. I find it to be true of POGGENDORFF'S *Annalen* so long ago as the year 1800. At the present time it is next to impossible to find any other system of weights and measures but the metric so much as occasionally named in any of the publications devoted to physics and chemistry in all Germany. Almost the same thing is true of the scientific periodicals of Russia, of Austria, of Denmark, and of Sweden. I have very recently looked through the principal journals of this class, published in the countries just named, and what I assert of them, I assert from personal knowledge. Men of science have adopted this

system, not only because of their approval of its principles, but because it is a labor-saving machine of immense capabilities. If you look into our own scientific journals and those of Great Britain, you will find that, what has just been remarked of the journals of the continent, is true to a considerable extent of them also; and to an extent constantly increasing. Our analytic chemists use the metric system altogether; and with our physicists its use is becoming every day more general. With the science of the world on its side, therefore, the metric system has a powerful ally, which, added to the influence of the material interests enlisted in its favor, must make its final triumph inevitable.

THE SOCIAL SCIENCE ORGANIZATIONS FAVOR THE SYSTEM.

It will be understood that the scientific associations and the scientific men to whom reference is here made, are those who deal with the exact sciences, or employ themselves with material nature. Truth is the object of their search: with the uses of the truth discovered, or its relations to the human race, they do not concern themselves. There is, however, another class of inquirers, one to which I have earlier referred, whose influence on the question before us is destined to be powerfully felt, who have created in these modern times a new science of their own, taking as their subject precisely what the former class omits—the rela-

tions of truth to humanity. In the scope of their inquiries, they are most widely comprehensive, embracing equally all truth—the moral and the psychological no less than the physical. They call their science social science; it might be called the philosophy of philanthropy, for its object is to discover and remove the causes of human wretchedness, whether they be material, political, mental, or moral; and to place the human race in circumstances where it may work out for itself a destiny the noblest of which it is by nature capable. It is not through a merely native taste or bias, that these men pursue the science they have created. Their science is to them more than a love—it is a religion. Their impelling principle is deeper than enthusiasm—it is an earnest sense of duty. These men, therefore, belong to that class whose characters command the highest respect, and whose opinions carry the largest weight among their fellow-men. They, too, like others, have availed themselves of the powerful machinery of associated effort. In many enlightened lands, social science associations hold their periodical meetings, and by means of the reports of their discussions scattered among the people through the public prints, and the wide circulation of their own memoirs and journals, powerfully impress the public mind. Within the past ten or fifteen years, there has sprung up, in addition to the national organizations here referred to, an international social science association also, composed of men of every land, many of

them men whose names have a world-wide celebrity. The last meeting of this influential body was held in 1867; the next is to assemble in England, during the ensuing fall. Among other measures adopted at the meeting preceding the last, was the appointment of a committee to draw up a complete code of international law, to be presented for acceptance to the governments of all nations, and to be binding upon all such as shall assent to its provisions. The code is to comprehend two grand divisions, presenting the rights and duties of nations, first in peace, and secondly in war. The first of these divisions, relating to peace, is now complete, and will be presented to the association at the ensuing meeting. I am authoritatively informed that it embraces provisions making the metric system of weights and measures the common system for all the nations accepting the code; and there can be no doubt that the association will cordially concur with their committee as to these provisions. The social science associations may therefore be regarded as another powerful influence, silently acting throughout every corner of every civilized land, and throwing its whole strength in favor of the universal adoption of the metric system of weights and measures.

THE SYSTEM HAS BEEN RECOMMENDED BY INTERNATIONAL CONFERENCES.

There are other influences co-operating with this, in which the political principle is combined with the

social. The importance of endeavoring, in some way or other, to arrive at a common system of moneys, weights, and measures, has been felt by governments to be sufficient to justify the calling of international conferences to discuss this very thing. Now, though these conferences have not resulted as yet in bringing actually to pass the object for which they were summoned, still they have furnished an independent and an important indication of the extent to which public opinion everywhere is turning toward the metric system, as destined inevitably to be at length the system of all mankind. For while the money question has invariably elicited a large variety of opinion, and while an agreement of all the delegates upon any one proposition for the unification of the coinage of the world has been found extremely difficult, if not impossible, to secure, yet, as to the question of weights and measures, there has been no difficulty whatever. At the Paris conference of 1867, for example, twenty-two nations were represented, including the non-metric nations, Russia, Austria, Sweden, Norway, Denmark, Great Britain, the United States, and Turkey. The report of the committee in favor of the metric system was an admirable document, drawn up by the celebrated De Jacobi, of St. Petersburg; and it received the absolutely unanimous concurrence of all the delegates of all the nations. It is impossible to regard a phenomenon of this kind without seeing in it both an indication and an influence—an indication showing the march of opinion hitherto,

and an influence which cannot fail to be felt in accelerating this march.

THE INTERNATIONAL STATISTICAL CONGRESSES HAVE ADOPTED THE SYSTEM.

But there is still another and a still more powerful influence, uniting, like that last mentioned, the social and political features, which has been gradually taking shape and gathering strength within the past twenty years, which is also destined to act powerfully in favor of the speedy creation of an international system of weights and measures, and which is already committed in advance to the metric system for that purpose. In explanation of this remark I will state that, about twenty years ago, there was assembled at Brussels, on the invitation of the government of Belgium, a convention which assumed the name of "The First International Statistical Congress." This body consisted of two hundred and thirty-six members, who were about equally divided between Belgium and foreign countries, thirty-five being delegates appointed by governments. This first convention, held in 1853, has been followed by six others; of which the second was assembled in Paris in 1855; the third at Vienna, in 1857; the fourth at London, in 1859; the fifth at Berlin, in 1863; the sixth at Florence, in 1867; and the seventh at the Hague, in 1869. The spirit in which these great international assemblages originated, is explained in the following brief extract

from the report of Mr. S. B. RUGGLES, of New York, ..e delegate from the United States* to the convention of 1869, at the Hague, recently published by order of the United States Senate. "The distinguished promoters of the first congress, at Brussels," says Mr. RUGGLES, "had seen enough of modern statemanship to know that the government of nations, in their present state of material progress, cannot be wisely conducted without a thorough knowledge of quantities;" and that the systematic collection and philosophical arrangement of the "quantities" needed for showing the general condition of nations, is "an indispensable preliminary to any recommendation by an international congress of any measures seeking to promote the general welfare." In accordance with this spirit, "the official report (or '*compte rendu*') of the congress at Brussels shows its labors to have been largely devoted to the scientific analysis of quantities, in subjects interesting to all nations, to be used as a basis of a uniform system of inquiries, in actually collecting the necessary facts." And in like manner all the succeeding congresses have devoted themselves sedulously to the labor of bringing together every description of facts obtainable, in regard to the actual wealth, the productions natural and artificial, the condition of industry and commerce, the character of the social institu-

* Mr. RUGGLES also ably represented the United States in the fifth congress, at Berlin.

tions, and other matters of kindred interest, relating to the various peoples who make up the population of the globe. The results of such inquiries could only be made available for any useful purpose, on the condition that all the "quantities" so ascertained should be reduced to a form in which they could be compared; on the condition, therefore, that they should be expressed in denominations of the same system of weights and measures; and, accordingly, it has been urgently recommended by all these congresses that all statistical statements everywhere should be made in terms of the metric system. The seventh and most recent of these assemblies, moreover, inaugurated a work which, if efficiently prosecuted, will be in honorable harmony with the magnificence of the idea which originated these congresses of the nations. The nature of this work is thus stated by Mr. RUGGLES: "On the last day of the session, Dr. ENGEL, the distinguished director of the statistical bureau of Prussia, presented to the body, in general assembly, a plan of great comprehensiveness and importance, which had been matured after full discussion in the appropriate section, and conversation with most of the governmental delegates. It provides for a full and systematic exploration of the whole field of international statistical inquiry, which is divided for that purpose under twenty-four different heads, each to be the subject of a separate investigation by the delegates or members from some one of the nations to be selected, and which is to

embrace the statistics under that head of all the nations. This great work, if fully carried out, will furnish, in convenient encyclopedistic form, a systematic series of carefully prepared reports on most of the subjects of highest interest to the statesmen and legislators of the different nations. Editions of at least two thousand copies of each report are to be published in uniform octavo volumes, under regulations presented in the plan, which was unanimously adopted by the congress, with strong expressions of approbation."

Without the metric system, the vast mass of information thus collected would be unavailable—the encyclopedia would be illegible. This system has, therefore, thus become something more than a mere instrumentality in the service of statistical science; it has become even an integral part of the science itself. Henceforth the two are so irrevocably wedded that they can be separated no more forever.

IMPORTANCE OF THE INTERNATIONAL STATISTICAL CONGRESS.

The "International Statistical Congress" may now be regarded as an established institution. Its eighth meeting in the order of succession will be held some time during the course of the year 1871, and probably in St. Petersburg. Already the influence of its deliberations, of the published results of its labors, and of the spirit of comprehensive statesmanship which it has inculcated and fostered, is beginning to be sensibly

felt, and with each successive decade of years it will be felt with a power continually increasing, in educating the minds of the peoples, and in moulding the counsels of governments into harmony with the great principle that nations only then consult their truest interests when they consult the common interests of humanity.

EARLIEST SUGGESTION OF THIS INSTITUTION BY MR. ADAMS.

The germ idea of an agency which, with time, has developed itself into a power capable of controlling, and destined so largely to control, the future of human history, is to be found in the report of Mr. ADAMS to the House of Representatives of the United States Congress, made in 1821, which has been already cited in this paper. Though this report discouraged the adoption of the metric system by Congress, and though its reasonings had the effect undoubtedly to impress the popular mind in this country with the conviction that the introduction of the system into these states is hopeless, yet the author himself was as deeply imbued with admiration of this system, considered as a scientific creation, as the warmest of its advocates; and no one felt more profoundly than he, how great would be the boon to humanity, if one uniform system of weights, measures, and moneys could be made to prevail everywhere throughout the world. In the view of his large and statesman-like intellect, very many of the embar-

rassments which attend intercourse between nations, spring from the selfish and narrow legislation which looks only to the immediate interests or convenience of particular communities, and disregards the results to the great family of man. To him, all nations and all races are brothers by blood, inheriting the earth as their common patrimony; and though, in the existing state of human society, it is necessary that the artificial lines which divide states from each other should be preserved, it is eminently desirable that, for as many purposes as possible, they should be kept out of sight. He therefore proposed that the President of the United States should be authorized to invite the governments of the several states having diplomatic relations with that of the Union, to appoint delegates to a congress of nations, charged with the duty of deliberating upon measures likely to be promotive of the general welfare; but, foremost and especially, upon the possibility of establishing a uniform system of weights and measures for all mankind. That this important proposition was productive of no immediate result, is attributed by Mr. RUGGLES, and with apparent justice, to the political condition of Europe during all the earlier portion of this century; and especially to that compact of political rulers for the suppression of liberal thought, and the stifling of all freedom of political discussion, which the momentous events of recent history have since shattered, known as "The Holy Alliance." Happily, however, at length, to use the vigorous words of Mr.

RUGGLES, "We find the germ of the general convention, planted by the far-seeing sagacity of Mr. ADAMS, in 1821, though slumbering for a generation beneath the surface, actually fructifying in 1853, when the first general assemblage of nations by government delegates, and really international in its objects, was convened in Brussels."

From this epoch dates a new era in the history of the world's legislation. For the enlarged views of the reciprocal duties, as well as of the true interests of nations, in which this great general movement originated, are destined, through its instrumentality, to impress themselves more and more completely upon human institutions; until statutes shall at length cease to be monuments of ignorance, prejudice, or ignoble jealousies, and the aim of all laws shall be the greatest good of the greatest number. One most important result has already been secured by the action of these congresses; in that, so far as the science of statistics is concerned, so far, we may even say, as the successful conduct of governmental administration is concerned, it has made the metric system of weights and measures a system of universal necessity, and rendered a familiar acquaintance with it absolutely indispensable to every statesman, every publicist, every teacher or student of political economy, and every enlightened lawgiver throughout the world.

ALL CAUSES CONSPIRE TO RENDER THE ULTIMATE TRIUMPH OF THE SYSTEM INEVITABLE.

It thus appears that there are powerful, permanent, and all-pervading influences steadily at work to advance the cause of metrological reform; and that these influences conspire to forward the movement in the direction which it had already spontaneously taken—that is to say, toward the ultimate prevalence of the metric system of weights and measures over every other. It further appears that the actual progress which the movement has made since the century began, has by far exceeded anything which could have been reasonably anticipated, and has been sufficient to justify the most sanguine hopes for the future. When we consider, for example, that, at the close of the last century, the simple measure of length called the foot had not less than sixty different values still—probably many more—actually in use in different parts of Europe; and that, in 1867, at an Exposition in which the measures of all the world were all brought together, there could be found only eight of this discordant class still surviving; argument would seem to be needless in behalf of a cause which is so manifestly making its own way unaided. Whether our own people are to be participators in this grand movement, which has already gone so far, is not with me a question of probabilities, but only a question of time. I expect very little to-day, and not much to-morrow;

but beyond to-day and to-morrow there are other days coming, from which I expect everything. I know the strength of early associations and the power of rooted habits; I know how fondly men will hug the evil which is familiar and reject the good that is strange. I know that the Greenlander greatly prefers his icy mountains to the coral strands of India. My inference is, that we must look to a generation which shall not be so mentally one-sided as ours; a generation in whose training the good shall not be placed at so tremendous a disadvantage as it has been in our own; a generation which shall bring to this great metrological question a judgment at once fair, candid, unbiased, and unwarped by the prejudices which mislead and bewilder us; to pronounce the impartial decision for which, it must be sadly admitted, we seem disqualified ourselves. And such a generation, gentlemen, permit me to predict, will yet be born upon the American continent, if it is not born already.

II.—*Objections to the Metric System considered.*

PRELIMINARY REMARKS.

In all that I have hitherto said, I have not dwelt for one moment upon the intrinsic merits of the metric system itself. I have not thought that necessary. I am addressing intelligent men who know the system, and who know that, for the whole circle of our dealings with quantities, it stands, for easiness of apprehension, for convenience of use, and for the degree to which it facilitates reductions, precisely where our Federal currency stands, among systems of money. The simplicity of the relations, moreover, by which it connects the measures of surface, of capacity, and of weight, with the linear base, is such as is nowhere else found; and such as to make of the system a powerful intellectual machine, and an educational instrumentality of inappreciable value. All this I pass by. But I cannot pass so lightly by the objections which have been urged against the system, and of which, in my view, the importance has been, in most instances, exaggerated beyond all reason; since, through the wide circulation of the report of your committee on this subject, the high authority of this learned convocation has been made liable to be popularly regarded as attesting their gravity. Consistently with the duty imposed upon me on this occasion, therefore, I cannot pass them by; although the extent to which I have

already trespassed upon your indulgence forbids that I should examine them with all the fulness that I could desire.

FIRST OBJECTION—THE UNIT BASE TOO LARGE.

We are told, then, first, that the linear unit of the system is too large. Too large for what? Too large, in the words of your committee, "to be apprehended by a young and uninstructed mind." This is something which I confess that *I* do not apprehend. A metre, I suppose, can be brought into the schoolroom; and can be seen without difficulty, even by a very small boy, from end to end. I remember, when I was a very small boy myself, seeing something brought in which was about as long as a metre; and if I did not apprehend it at the time, I was at least very apprehensive of it.

But Mr. ADAMS says the metre is too long for a pocket rule. "Perhaps," he remarks, "for half the occasions which arise in the life of every individual for the use of a linear measure, the instrument, to suit his purposes, must be portable, and fit to be carried in his pocket. Neither the metre, the half-metre, nor the decimetre is suited to that purpose." What then would Mr. ADAMS have? Would the foot rule fit into a man's pocket more conveniently than the decimetre? Does any man carry a foot rule in his pocket in any other than a folding form? And cannot a folded metre be carried in the pocket as easily as a folded

foot? I at least find it so; as this rule proves, which I here present you. But since we have not yet adopted the metre as our unit, and since, after all, in spite of what Mr. ADAMS says, or what anybody else says, it happens to be notorious that a foot is *not* the measure which, "for half the occasions which arise in the life of every individual," is the most useful; the portable measure which we commonly find in men's pockets is a tape measure of a yard or a fathom in length, put up more compactly than is possible for any rule, whether long or short.

As to what *ought* to be the value of the standard length-unit, opinions differ. The British standard is a yard. The Russian is the sagene, more than twice as long. Prof. PIAZZI SMYTH almost fanatically attaches himself to the inch, a measure which he believes with implicit faith to have been divinely given to CHEOPS, builder of the great pyramid, and again to MOSES in the wilderness; and in what he, no doubt, regards as the great work of his life, he uses no other to express the largest dimensions.

But it is also said that there are things to be measured in the common affairs of life that are less than a metre. I should suppose so. There are likewise many things to be measured, less than a foot, or an inch. They measure these things in England even though the yard is their legal standard. In mechanical engineering, in France, the centimetre is the unit; in physics the millimetre. It does not unfit them for these uses,

that their names happen at the same time to be expressive of relation to the standard. The metric unit of weight in commerce is the kilogramme ; in analytic chemistry and pharmacy it is the gramme. The metric unit for dry measure is the hectolitre ; for liquid measure, it is the litre; the metric agrarian unit is the hectare ; the metric itinerary unit is the kilometre. It is, in fact, one of the merits of the system, that while, like all other systems, it allows any denomination to be made a unit measure for special purposes, yet it allows also instantaneous transformations from one denomination to another without changing a figure, but by the simple removal of a point. This cannot be done in non-decimal systems. The inch, for example, is with us the unit of the mechanical engineer and the draftsman. The rod is the farmer's unit of distance. But to reduce inches to feet you must divide by twelve, changing all your figures ; and to reduce rods to feet you must multiply by sixteen and a half. This plan does not seem to me preferable to the metric. When your committee say that in their opinion "other units besides the base-unit should be used, as secondary bases for collections of numbers," I agree with them. It is what, in the employment of the metric system, I have always been in the habit of doing myself. But if, when they say this, they mean to say that values expressed in units of these secondary bases ought *not* to be transformable by the simplest processes possible

into units of the standard base, my impression is that they will fail to carry the world along with them.

SECOND OBJECTION—THE DECIMAL DIVISION TOO DIFFICULT.

Another serious difficulty is started, of an educational character. Ten, it seems, is a difficult number to grasp; and one-tenth part is a still more difficult fraction. We can never know anything about one-tenth, "until we have divided the unit into two equal parts, into three, into four, and so on up to ten." Since this is the case, it is melancholy to reflect how much more objectionable is our actual system of weights and measures than the metric; since it will be necessary to divide the foot into two equal parts, into three, into four, and so on all the way up even to twelve, before the faintest conception of an inch can begin to dawn upon our minds; and when we turn our attention to the pound and the ounce avoirdupois, the formidably protracted extent of this unavoidable operation becomes quite disheartening. Still, however grave this business of ten may be, I suppose that our children must some time or other know something about decimal arithmetic; and they will have to know something about it whether they learn the metric system or not. If they know it, they know the system, all but its nomenclature; if they don't know it, then I can conceive no educational machinery better suited to make them know it, than the visible magnitude of the

metric measures placed before their eyes. The question is not whether we shall teach the metric system to babes, but whether we shall teach it along with the arithmetic, and as a part of the arithmetic, which boys must learn at any rate. The objector does not apparently discover that his argument is no less damnatory to our Federal currency than to the metric system; yet my observation in the streets of New York satisfies me that *gamins* of very tender years, without having enjoyed the advantages of scholastic culture, or having been carefully and systematically carried through the mental operation of dividing the unit into two parts, into three parts, into four parts, and so on up to ten, acquire an acute appreciation of the relative value of a dime stamp and a nickel.

THIRD OBJECTION—THE DECIMAL DIVISION UNSUITABLE FOR PRACTICAL PURPOSES.

It is objected again that, while the decimal ratio is infinitely more favorable to calculation than any other, yet for sensible objects, and for the daily purposes of life, the binary subdivision is to be preferred. If so, then let us use the binary so far as convenience may demand. There is no need on this account to reject the decimal, which for purposes of calculation is of priceless value. No harm is going to arise from employing both. We divide the dollar certainly into halves and quarters, to our great convenience; and the decimal system of the Federal currency is none

the worse for that. We used to divide it into eighths and sixteenths even; and Mr. ADAMS says that, if the Spanish mint had not furnished us with coins representative of these values, we should have been obliged to coin them ourselves. Yet within ten years after Mr. ADAMS wrote, we had effectually swept out all this fry of foreign coinage, and nobody now perceives the want of it. Again, the Swiss pound is half a kilogramme. Take half any number of Swiss pounds and you have kilogrammes. Double the number of kilogrammes and you have Swiss pounds. The Swiss, moreover, use both the decimal and the binary subdivision. I presume they would not do this if they did not find it for some purposes useful, as we do in our Federal currency. The Swedes, some fifteen years ago, introduced the decimal subdivision, but they still retain some binary relations. Some such binary relations are recognized also by the French law; but it does not therefore follow, as your committee infer, that this fact "must give rise to much confusion." Neither is it true, as they also maintain, that we cannot adopt the essentials of this system without "adopting it as a whole and excluding every other:" by which I understand them to mean that we shall not even adopt metric values for our units, as Denmark has done, and as Austria has done, and as Turkey has done to a certain extent, without adopting the nomenclature throughout, and sternly prohibiting the use of all binary division; or that we shall not adopt if we

please the decimal relations, as Sweden has done, without adopting either metric values or the nomenclature; nor adopt the metric values and the decimal system complete, and yet reject the nomenclature, as Holland continued to do for half a century, and has only ceased to do within the last two years. Surely, things that other people have done, we may do; nor is there going to be, as your committee apprehend, any "fierce conflict" about the matter, nor any need to talk about "the spirit of a free people," or to insist on the fact that Americans are not habituated to "blind obedience to imperial edicts."

THE SPIRIT OF METROLOGICAL REFORMERS MISAPPREHENDED.

Can it not be understood that nobody of the great party who are seeking metrological reform and perfect international accord on this important subject, is bigotedly devoted to the metric system for its own sake; or resolutely determined to yield nothing that is in it, or to accept nothing that is not in it, on any consideration whatever? Their battle is for a *common* system, be that what it may; but if they believe that that common system will be found at last to embrace the main features of the metric system, they are not to be told that they shall have nothing else, if anything else superadded to it will make it either theoretically or practically better. Mr. ADAMS wrote fifty years ago. What he wrote seems to have impressed your

committee much more forcibly than all that has happened since. But the world has moved since the time of Mr. ADAMS ; and it is perhaps not quite in order to tell us that, if we think it a good thing to divide by ten, we shall never be permitted to divide by any other number so long as we live. The first great point to be secured is commensurability of unit bases. That point once gained, the battle is substantially over. As for nomenclature and subdivisions, however important these matters may be, their importance is secondary, and they may be attended to afterwards.

THE DANGER OF JUMPING AT CONCLUSIONS.

Sweeping propositions are rarely wholly true. It is not a fact that binary subdivisions of weight and measure are always necessarily the best. In small dealings, the convenience of buyers and sellers is best consulted, when the multiples and submultiples of quantities correspond with the multiples and submultiples of coins. If a pound of any commodity costs twenty-five cents, it would suit all parties who use the Federal currency better, if we could divide the pound evenly into five parts, than it does now to divide it into four. Nothing is more certain than that quantities bought and sold, and the instrument of purchase and sale, should be subject to the same law.

COMMENSURABILITY OF UNIT BASIS FIRST TO BE SOUGHT.

But, as just remarked, the first point and the great point to be secured is, commensurability of unit bases. This can be accomplished, if we please, with great facility. Our foot differs from three decimetres by a very inconsiderable fraction—less than two-tenths of an inch. If we make this slight change in the length of our foot, we are in harmony with nearly all of continental Europe. As for the other measures, they present no difficulty when the measure of length is once adjusted; for measures of length determine the dimensions of permanent constructions, while pounds and gallons are for ascertaining quantities of substances usually perishable. Men are disposed, therefore, to adhere with more obstinacy to their measures of length than to those either of weight or of volume.

PAST INSTABILITY OF BRITISH MEASURES AND WEIGHTS.

Mr. ADAMS'S report shows that, in the past history of England, nothing has been more unstable than the value of the pound, the bushel, and the gallon. There was a time when the gallon of liquid capacity contained only 216 cubic inches—in one sense a judiciously chosen value, since it was just one-eighth part of a cubic foot. The dry measure gallon contained, at the same time, 264.34 cubic inches, corresponding to a bushel of 2,114.68 cubic inches. And there was a

ratio connecting the liquid and dry measures, which was that of the specific gravities of wheat and Gascon wine. Mr. ADAMS is quite enamored of this duplicity, which extended to the weights as well, between which the ratio has been pretty closely preserved down to our time. But this liquid gallon went on, as Mr. ADAMS explains, to be successively 217.6 cubic inches, 219.43 cubic inches, 224 cubic inches, and finally, as with us now, 231 cubic inches. As to the bushel, it seems to have had all sorts of value. By statute of 1496, passed in the reign of HENRY VII., it seems to have been ordered that this measure should contain 1792 cubic inches; but this statute was never carried out. There are two exchequer standards of this reign, one of 2124 cubic inches, and one of 2146 cubic inches, which latter is called the Winchester bushel. But then, under HENRY VIII., we have the large bushel of 2256 cubic inches, from which came the ale gallon of 282 cubic inches, so long in use with us. A bushel afterwards appeared, of 2148.5 cubic inches; and subsequently the Winchester bushel was found to have somehow worked its way up to 2150.42 cubic inches: at which value it was, in 1701, made the standard in England, and so became the standard with us, as it continues to be yet.

SUMMARY PROCEEDING OF THE BRITISH PARLIAMENT ON THE SUBJECT.

But just three years and a half after Mr. ADAMS so strongly expressed his regrets at the destruction of the beautiful "uniformity of proportion" contemplated by the theory of the British measures, the British Parliament took this whole business in hand. Instead of improving the capital opportunity afforded them of correcting the irregularities which his report signalizes, they quietly struck out of existence every measure of capacity in use, whether wet or dry; and established the system of *imperial* measures, wherein the bushel contains 2218.1907 cubic inches, and the gallon 277.-2738 cubic inches, to be used equally for commodities of all descriptions. This was a tolerably formidable change and a tolerably sudden change; but it occasioned no insurrection; nor did the people even run after the carriages of the ministers, shouting "give us us back our bushel;" as we are told they shouted in 1752, "give us back our eleven days," when the Gregorian calendar was first introduced into England. Changes of metrological systems, then, are possible, and are possible even for us, without provoking "fierce conflicts." All that is necessary is that the people should know what they are, and should feel that they are desirable.

THE COMMITTEE OF THE CONVOCATION THEMSELVES ADVOCATE REFORM.

Your committee themselves are not adverse to all change. There is one modification of our system of weights which they actually propose to our acceptance. The recommendation is made moreover so impressively, out of a sense of "duty, plain and imperative," that for one I was prepared for something startling; for at the very least a proposition to do away forever with the perfectly unnecessary Troy pound. I am compelled to confess my disappointment. The proposed innovation so solemnly introduced is explained in the following words: "In analyzing these weights, it is found that the ounce in the apothecaries' weight and the ounce in the weight Troy are identical, and that each exceeds the ounce avoirdupois by its eighty-three-thousandth part very nearly; hence, if the ounce Troy, or the apothecaries' ounce, be diminished by its eighty-three-thousandth part, the result will be the ounce avoirdupois, or the one-thousandth part of the weight of a cubic foot of distilled water, and then these three weights will have a common unit."

I have pondered this passage profoundly, but I have not been able to see my way to the bottom of it. It has been my lot to be compelled to transform Troy ounces into avoirdupois ounces very frequently; but I have always found the difference to be 42.5 grains,

while it is here apparently hardly six one-thousandths of one grain. Presuming, however, that something may have been intended which is not said, and that, at any rate, it is designed somehow to make the Troy and apothecaries' ounce equal to the avoirdupois ounce, I accept this proposition as a concession so far as it goes to the cause of uniformity and simplicity; but I ask what justification can exist, after abolishing the smaller denominations, which alone are used by the jewellers and dealers in bullion, or even by the druggists (for the wholesale drug trade is carried on in avoirdupois pounds)—what justification can exist after this, for retaining the useless pound of twelve ounces.

I would point out further that, since the ounce, after being reduced by nearly its eleventh part, is still, according to the proposition of your committee, to consist of four hundred and eighty grains, the grain must accordingly be reduced in the same proportion; so that all the confusion which could arise in pharmacy and the trade in precious metals from changing the grain for the milligramme, whereby something might be gained, will be here introduced without gaining anything at all.

FOURTH OBJECTION—THE DECIMAL DIVISION HAS FAILED, AS APPLIED TO THE CIRCLE.

It has been furthermore urged as a fact very injurious to the pretensions of the metric system, that this system has never been permanently applied to the

division of the circle, to which, if to anything, it ought to be peculiarly adapted. Those who use this argument ought to remember that the Arabic numerals, the symbols of algebra, and the division of the circle, are three things (and the only three things, I believe), which were the same for all civilized mankind when the metric system was created. To change the law of circular division was to introduce diversity where uniformity prevailed before; and also to destroy the usefulness of a vast scientific literature which had been founded on the sexagesimal division. Yet the French did make the experiment of dividing the quadrant centesimally, both in tables and in instruments; and what was thought of its convenience by the ablest astronomers and geodesists of that day may be inferred from the following incidental remarks of DELAMBRE, in his description of the operation of measuring the great French meridian arc. "Three of our four circles," he observes, "were divided into decimal grades or degrees, each having the value of $360° \div 400 = 0°.9 = 540' = 3240''$. This division is much the most convenient for the uses of the repeating circle, and would be equally so for the verniers of all instruments whatever. Many persons hold to the old system by habit, and because they have made no use of the new; bnt no one of those who have practised both, will willingly return to the old."

When the metric system shall be universal, it is probable that the decimal division will be once more

applied to the circle. Nothing could be less convenient than the sexagesimal which is now employed. And in point of fact, this law of subdivision has been already abandoned for all values below seconds; such values being now invariably expressed decimally, though, two or three hundred years ago, it was carried to thirds, fourths, and even fifths, as may be seen in any old astronomical work, or in DELAMBRE'S *History of the Astronomy of the Middle Ages.* I regard this objection therefore as without foundation.

FIFTH OBJECTION—THE UNIT OF LENGTH SHOULD BE SOME DIMENSION OF THE HUMAN PERSON.

But it is apparently a very strong point with most objectors to the metric system, that our present measures of length have their representatives—the assumption is that they have their prototypes—in the dimensions of some parts of the human body. Thus, your committee say, the foot "was undoubtedly adopted as a standard of measure from the part of the body from which it takes its name." Some foot was undoubtedly so adopted, but what foot? The Greeks used the foot earliest, and the Olympic foot is said to have been the measure of the foot of HERCULES. But there were foot measures in use among them of several other magnitudes; and while it is difficult to know with certainty what any of them were, compared with ours, it is not difficult at all to ascertain that they differed widely among themselves. Thus the authorities state that the

Macedonian foot was 14.08 inches, the Olympian 12.14 inches, the Pythian 9.72 inches, and the Sicilian 8.75 inches. Here, in the earliest history of this measure, we have the largest room for choice. In more recent times, the diversity has been greater still. Thus in Italy the foot was, not long ago, 11.62 inches in Rome; 13.68 inches in Lombardy; 23.22 inches in Lucca. In France, it was 9.76 inches in Avignon; 9.79 inches in Aix-en-Provence; 10.57 inches in Rouen; 14.05 inches in Bordeaux; while the *Pied du roi*, for France generally, was 12.79 inches. In Switzerland, it was 10.52 inches in Neufchatel; 11.33 inches in Rostock; 11.99 inches in Basel; and 19.21 inches in Geneva. In the Spanish Peninsula, it was 10.12 inches in Aragon, and 10.96 inches in Castile. In Germany, it was 9.25 inches in Wesel; 10.89 inches in Bavaria; 10.998 inches in Heidelberg; 11.45 inches in Göttingen; and 13.12 inches in Carlsruhe. In the Netherlands, it was 10.86 inches in Brussels, and 11.28 inches in Liège. These examples will suffice, but there are plenty more behind.

It can hardly be supposed that all these measures were taken from the human foot; it is hardly probable that any of those used in the later centuries were so. The name has been perpetuated from a very early time; but the thing named has either lost by degrees its original value, or it has been arbitrarily changed. As to the origin of the British foot, it is pretty easily explained. There is no reason to doubt the account

commonly given of the adjustment of the yard from the arm of HENRY I., in 1101. The foot is certainly derived from the yard, which has always been the standard of length in England, and is simply the third part of that measure. I know that we are continually told that our American foot is in length but a fraction in excess of the average foot of man. It astonishes me that any one who has two feet to walk on himself should ever entertain this opinion. The length of the human foot is given in the *Encyclopedia Britannica*, (authority Dr. THOMAS YOUNG) as 9.768 inches. Upon how large an extent of observation this determination is founded, is not known; but the question in issue is pretty well settled in the volume of "*Investigations in the Military and Anthropological Statistics of American Soldiers*, by Dr. B. A. GOULD," published, in 1869, among the Memoirs of the U. S. Sanitary Commission. Nearly 16,000 individual men, volunteers for the army, of very various races and nationalities, were subjected to measurement, of whom about 11,000 were white, and the rest colored. Dr. GOULD says: "The mean length [of the foot] was found for no nationality to exceed 10.24 inches; and for none to fall below 9.89 inches; the value for the total being 10.058 inches," or about a twentieth of an inch above ten inches. This approaches much more nearly to a quarter of a metre than to a third of a yard.

Let it be understood that nobody is objecting to the foot measure. It is a very convenient measure to have.

If it were slightly modified so as to be equal to three decimetres, it would be more desirable still; but it is quite unnecessary to defend it on the ground that it is the measure of the human foot; and it is judicious not to do so, because that happens not to be the case.

However, the facility of measuring off the yard on the arm is a fact which furnishes to the objector firmer ground. We *can* do that. Sir JOHN HERSCHEL'S rule is: "Hold the end of a string or ribbon between the finger and thumb of one hand at the full length of the arm extended horizontally sideways, and mark the point that can be brought to touch the centre of the lips, facing full in front." Very well; now if you will carry the string or ribbon entirely across the lips, and mark the point that can be brought to touch the angle of the jaw or the lobe of the ear, you will have a metre. Or, if you carry the ribbon across the breast instead of the lips, and bring it to the point characteristic of that part of the person, you will have a metre once more.

The breadth of the palm is a decimetre; the breadth of the little finger at its extremity is a centimetre. A pace is an artificial step, and not a natural one; but suppose that it were natural for us to stride three feet, or suppose, at any rate, that we have learned to do so; and suppose that a metre is too large a step to be easily acquired; a pace is practically nine-tenths of a metre, and any number of paces are reduced to metres by dropping a tenth part. Thus, fifty paces are forty-

five metres, and one hundred paces are ninety metres. This reduction is the simplest of all possible processes. Thus, I do not see that, by adopting metrical measures, we are going to be in the slightest degree disabled from finding, in the dimensions of our own persons or of our steps, all the means of effecting rough measurements which we possess at present; and this objection falls to the ground.

SIXTH OBJECTION—AN OBJECTION OF THE COMMITTEE—WE CANNOT CONVENIENTLY DEAL IN ONE SYSTEM AND THINK IN ANOTHER.

But there is still another practical objection which is so perfectly well founded, that I hardly know what to say about it; so that I am not sure that the truest wisdom in me would not be to let it alone altogether. It is the undeniable truth, that, *if we give up our present measures we shall cease to have them any longer.* "What follows?" say your committee with anxiety; "we have blotted from the mind of the nation the foot, and a knowledge of every measure into which it enters as a unit." This is evidently a serious business. It reminds us of the sad case of the lad, who, having eaten his cake, desired to have it again. The committee go on to explain that, instead of twenty-five feet we shall have to say something else; and instead of one hundred and forty-five miles we shall have to say something else still. And exploring the extent of the calamity, the committee become gloomily figura-

tive ; and, speaking with deep emotion of "the cubic foot, known wherever the English language is spoken," they tell us that this cherished object "is also gone, and in the twilight of its existence, we grope about for a substitute." I do not deny that this is eloquence ; but I respectfully submit that it is not argument. There cannot but be some of us who will consider that this tenderly lamented cubic foot, with its inconvenient numerical relation to the cubic inch of 1728 to 1 ; and its more inconvenient relation to the common unit of liquid capacity of 1728 to 231 ; and its even still more inconvenient relation to the unit of dry capacity of 1728 to 2,150.42, is very well out of the way.

I will not attempt to follow the committee further in their lament. But I cannot omit to notice, in passing, the perplexing embarrassment of the honest man who, setting out to purchase the convenient quantity of fourteen pounds of beef for his dinner, after there have ceased to be any pounds, is astounded at finding that he will be compelled to pay for the amazing number of grammes expressed by the figures six thousand three hundred and fifty-six ; or in case that he is bankrupted by this huge demand, will be permitted to compromise the matter only on condition of buying six kilogrammes, three hectogrammes, five decagrammes, and six grammes. I wish to present a parallel to this. I go to my tailor for a coat, and he states to me the price, in a sum expressed by the four digits named above, in the same order, viz., six, three, five, six.

The committee has given the general rule for readings concrete decimal numbers, as follows: "All the readings are made in the lowest unit." Hence, the cent being the lowest money unit involved in the price named, my tailor is under the necessity of informing me that I can have the coat for six thousand three hundred and fifty-six cents; and it will not be lawful for him to vary the form of expression in any manner unless to say, by way of alternative, that he will give me the coat for six eagles, three dollars, five dimes and six cents.

I would, however, advise the unfortunate man who finds so much trouble with his marketing, not to buy his meat by the pound after pounds have gone out of date; but to content himself with a round six kilogrammes, or, in case he is very hungry, say six and a half.

SEVENTH OBJECTION—THE ADOPTION OF THE SYSTEM WILL INVALIDATE LAND TITLES.

As it respects the objection that the introduction of the new measures would invalidate the titles to lands held under old surveys, nothing can be more imaginary. No legislation on this subject can be retroactive—it would not be constitutional if it were. The registry of deeds in the past would continue to have the same validity as now. In making a new deed in the future, nothing would be easier than to translate the language descriptive of linear and superficial di-

mensions from one form of expression to the other. Changes would thus come on gradually, as property should change hands. Deeds have to be made anew when sales are effected, and only then. The labor of making them in one form or the other is precisely the same.

NINTH AND TENTH OBJECTIONS—THE BASE NOT WELL CHOSEN, NOR CORRECTLY DETERMINED.

One final objection, or pair of objections allied to each other and closely connected together, I have reserved to be considered last. Some gentlemen honorably eminent in science have criticised the metric system on the ground that its base is not well chosen. This base purports to be the ten-millionth part of a quadrant of the terrestrial spheroid. But it is said the earth is not a spheroid, being rather an ellipsoid of three unequal axes; whence it follows that the meridians are unequal, and that the metre, if truly the ten-millionth part of one quadrant, is not a ten-millionth of any other differently situated in the ellipsoidal surface. The polar axis of the earth, on the other hand, is the common minor axis of all meridians; it is a magnitude entirely unique; and, even if the earth were a true spheroid, there would be a higher degree of scientific fitness, there would be something on which the mind would dwell with more entire satisfaction, if we should take a fraction of that axis as the base of a system of metrology, rather than a fraction of any quadrant, or

any other known magnitude. This is the view of Sir JOHN HERSCHEL and of Capt. PIAZZI SMYTH, and if the whole thing were to be done over again, it would probably be the unanimous view of the scientific world. But the matter has gone too far now to change the base. In the meantime, therefore, there is no impropriety in saying, that it is by no means yet proved that the earth is an ellipsoid. Neither, indeed, is it proved that it is a spheroid, if by that word is to be understood a figure geometrically true. What *has* been proved may be understood from the following succinct statement.

SKETCH OF GEODETIC OPERATIONS CONDUCTED HITHERTO.

There have been measured upon the surface of the earth, in all, excluding re-measurements, some sixteen meridian arcs. Most of these are very short, not exceeding three or four degrees in length, and generally less than two. The longest of them all is the Russian arc, of twenty-five and one-third degrees; and the shortest, the first Swedish arc, measured in 1737, by MAUPERTUIS, of fifty-seven and a half minutes. Two short arcs have been measured on the American Continent, one in Peru and one in Pennsylvania. The latter, only about one and a half degrees in length, was measured by Messrs. MASON AND DIXON, in 1767, without triangulation, and is esteemed of comparatively little value. The Peruvian arc, which is rather more than three degrees long, was admirably triangu-

ated by BOUGUET and LA CONDAMINE, in 1735, and the two or three years succeeding. A short arc of about a degree and a half was measured at the Cape of Good Hope by LACAILLE in 1751. In this measurement, the effect of local attractions on the plumb-line was such as to lead to very erroneous conclusions. This arc has been recently re-examined and extended to more than four and a half degrees, by Messrs. HENDERSON and MACLEAR; this operation bringing to light the causes which had vitiated the former. A long arc of twenty-one and a third degrees has been measured in India. With the exception of the Indian, the African, the Peruvian, and the Pennsylvanian arcs (the last hardly meriting to be included in the enumeration), all the rest are in Europe, and are embraced within limits of longitude differing, at widest, but about twenty-seven degrees.

DETERMINATION OF THE EARTH'S FIGURE FROM GEODETIC MEASUREMENTS.

Now supposing the earth to be a spheroid, it matters not, for the determination of its figure, what are the longitudes in which meridian measurements are made, provided the latitudes are different; for on this supposition degrees in the same latitude are equal everywhere. Also, if the spheroid is oblate, the curvature in the higher latitudes will be less and the degrees longer than in the lower. Now, as in an ellipse, the linear amplitudes of any two arcs differently

distant from the apsides, along with the angles made by the normals at their extremities, suffice to determine the axis and the eccentricity, it was to be expected that a comparison of any two properly selected meridian arcs measured upon the earth's surface in different latitudes, would furnish constantly the same value of the polar and equatorial diameters, and the same value for the compression of the poles. But this expectation has been singularly disappointed. The international scientific commission which, in 1799, fixed definitely the length of the metre, in comparing the French arc with the Peruvian arc, made the compression of the earth one 334th ; but Messrs. LAPLACE and LEGENDRE, both eminent geometers, members of that commission, by comparing one portion of the French arc with another, made it, the first, 1-150th and the second, 1-148th. DELAMBRE, one of the geodesists who effected the measurement, deduced from his comparisons with the Peruvian arc, the value, one 312th, and afterwards one 309th. The French arc was subsequently extended southward nearly three degrees more ; making a total length of twelve and one-third degrees, when a recomparison with the Peruvian arc by DELAMBRE gave a compression of one 178th. The effect of these differences of result upon the calculated length of the quadrant of the meridian passing through Paris would not be very great, upon the hypothesis that the earth is really a spheroid ; for it happens that the French arc is so situated as to give very nearly the

value of the mean degree, independently of the eccentricity. But if the earth is an ellipsoid, it is evident that it is entirely wrong in principle to compare two arcs with each other, when they differ materially in longitude.

INVESTIGATIONS OF GEN. T. F. DE SCHUBERT.

Now it is a part of the history of this subject that, in the year 1859, Gen. T. F. De Schubert, an officer of the Russian army of distinguished ability, after a laborious series of comparisons of several arcs combined two by two in all possible ways (the arcs were eight in number, and the combinations twenty-eight), found such remarkable discordances, that he felt himself forced to the conclusion that the earth is not spheroidal, but must be ellipsoidal in form. The compressions found by him varied, for instance, between the wide extremes of one 14501st, and one 116th; and the difference between the largest and smallest value for the polar axis amounted to 362,126 feet, or 68.584 miles.

Now observe what these deductions prove, and what they do not prove. They prove certainly that the earth is not a perfectly regular spheroid, and in this they are corroborated by other evidences; but they do not prove it to be an ellipsoid. The corroborating evidences just alluded to may be slightly glanced at in passing. In the first place, the successive degrees of the French arc do not increase, in going northward, in

the manner they ought if the meridian is truly elliptical. And, secondly, it is true, that after that arc had been extended southward, as above mentioned, to the Island of Formentera, in the Mediterranean, the degrees at the southern extremity were found actually to diminish in going northward, instead of increasing, as in a regular ellipse they should have done.

Colonel EVEREST, also, the accomplished geodesist, who executed the measurement of the northern section of the great Indian arc, found that, when he compared the northern half of the northern section with the southern half of the same section, he obtained an eccentricity of one 192d; but that when he compared the southern half of the northern section with the whole southern section, the resulting ellipticity was one 390th, or only one-half as great. The values of the polar axis of the earth also, obtained from these comparisons, differed by 67,106 feet, or about 12.71 miles.

These facts (and many like them might be stated) are to be borne in mind in judging how far the method of General DE SCHUBERT, with the data thus far gathered to go upon, is to be trusted. This gentleman, concluding very properly that comparisons of arcs measured in different longitudes are unworthy of confidence, resolved to deduce values of the polar and equatorial diameters of each meridian, by such comparisons as that of Colonel EVEREST just described. But here his material is at once largely reduced; for

of the eight arcs employed in his previous comparisons, only three are long enough to permit the application of this method, viz.: the Russian, twenty-five and one-third degrees; the Indian, twenty-one and one-third degrees, and the French, twelve and one-third degrees. The British arc is now long enough to allow a fourth comparison (ten and a quarter degrees), but it is so nearly in the meridian of the French arc that it may better be treated as a prolongation of that. Gen. DE SCHUBERT divided each of his three arcs into two parts, as nearly equal as convenience would allow. From each he thus deduced a value for the major and minor axis of the meridional ellipse. If his hypothesis was true, the minor axes should have come out equal and the major axes unequal. The latter anticipation was realized, but the former only imperfectly so. The polar axis found from the Russian arc, compares pretty well with that found from the Indian; differing only about fifteen hundred feet, or rather more than a quarter of a mile; but the difference between the values of the same axis, as deduced from the Russian and the French, is fifteen thousand one hundred and sixteen feet, or nearly three miles. On account of this discrepancy Gen. DE SCHUBERT discards the French arc in this computation, and determines a value for the polar axis on the basis of the Russian and the Indian alone; giving, at the same time, quite arbitrarily, twice the weight to the former as to the latter. And with the axis thus determined and the aid of the Peru-

vian arc, he finds a third equatorial radius; which, combined with the Indian and Russian equatorial radii, enable him to place the axes of his imaginary equatorial ellipse. Finally, with the axes of the equator and their longitude, and also the equatorial eccentricity, he is able to compute the length of the equatorial radius corresponding to the French arc; and from that, the length of the theoretic French quadrant. Then, comparing this theoretic quadrant with the length of the same as deduced from the actual measurement of its ninth part, he feels himself justified in pronouncing the metre to be too short by the two hundredth part of an inch. I think it does not require a profound mathematician to see that the data on which this conclusion rests are too meagre to justify so important a deduction. The case is one to which Prof. HUXLEY'S witty remark upon the power of the mathematics may be properly applied. "The mathematics," observes the Professor, "may be compared to a mill of exquisite workmanship, which grinds you stuff to any degree of fineness; but, nevertheless, what you get out depends on what you put in." And here it appears to me that we are not yet prepared to put in material enough to furnish us with a grist worth carrying away.

INVESTIGATIONS OF CAPT. A. R. CLARKE.

Prof. AIRY perceived the weakness of this method and pointed it out. He suggested an improvement on it which is worth more, and his suggestion was taken up by Captain A. R. CLARKE, an accomplished officer connected with the ordnance survey of Great Britain. This method consists in bringing together the latitudes, determined both geodetically and astronomically, of as many stations as possible, upon selected meridian arcs; and then, all the elements of the problem being left indefinite, proceeding to ascertain what values given to the indeterminates will make the sum of the squares of the errors of latitude a minimum. He first presented his results to the Royal Astronomical Society, in 1860; and afterwards, having slightly modified some of his data, republished them in an appendix to a large volume issued in 1866 by the Royal Ordnance Survey. His last conclusion puts the metre in error one 172d of an inch. The number of latitudes employed by Captain CLARKE in this investigation is forty. Some slight variations made upon a portion of those in the Russian and the French arcs, between the first and the second determinations, amounting generally only to very small fractions of seconds, produced a sensible difference in the length of the polar axis, in the value of the compression, and in the computed error of the metre; reducing this last from one 163d of an inch, which was his original determination, to one 172d, as

given above. But Captain CLARKE himself regards the data as entirely insufficient to make a correct determination of the earth's figure a possibility. His own words are: "It would scarcely, I conceive, be correct to say that we had proved the earth not to be a solid of revolution. To prove this would require data which we are not in possession of at present, which must include several arcs of longitude. In the mean time it is interesting to ascertain what ellipsoid does actually best represent the existing measurements." And having found this, he proceeds next to apply the same method, *i. e.*, the method of least squares, to the object of ascertaining, secondly, what *spheroid* will best represent existing measurements; and he is brought thus to the conclusion that such a spheroid is nearly as probable as an ellipsoid; the numbers representing these probabilities being 154 and 138 respectively (where the smaller number indicates the greater probability). We may admit then that the ellipsoidal theory is slightly the more probable; and with this preliminary we are prepared to consider the two objections spoken of above.

CONSIDERATION OF THE NINTH OBJECTION RESUMED.

The first is, that the earth's meridians being unequal, the ten-millionth part of a quadrant, even if we had such a measure correctly, could be only the ten-millionth of one particular quadrant, so that the ideal of a natural standard everywhere present and belonging

equally to all the world must be abandoned. Still it cannot be denied that the quadrant chosen, though a particular quadrant, possesses the essential property of a standard, that is to say, invariability, quite as completely as if all the quadrants were equal. If this natural standard were intended to be, or were capable of being made, a standard of convenient reference, and not merely a standard of value; if, in other words, a tradesman, suspecting his metre to be in error, could adjust it by simply stepping out of his door and applying it to the earth's meridian; there might be some reason for complaint on the part of those, and they would be the majority of mankind, whose distance from the standard would deprive them of this facility. This not being the case, no practical disadvantage arises out of the inequality of the meridians, and it is only the simplicity of the original conception that suffers.

THE TENTH OBJECTION—DISCORDANCE BETWEEN THE ACTUAL AND THE THEORETICAL METRE.

The second objection to the base of the system—an objection which is often urged in a tone which implies that the objector regards it as nothing less than fatal—is that the metre is not, after all, exactly the ten-millionth part of the particular meridian from which it was derived. It is possible that it is not: nay, we may safely assert that it would be nothing short of a miracle if it were. We have glanced at the condition

of the problem of the earth's figure and magnitude in the hands of the geodesists. We have seen that every meridian measurement which has yet been made has served but to accumulate evidence that this figure is not geometrically regular, and is not probably, if words are to be applied with severe exactness, either spheroidal or ellipsoidal. It will easily be understood that a local irregularity actually affecting but a limited extent of a terrestrial arc, may, when it is allowed to give character to a whole circumference, lead to extraordinary conclusions; and we have seen the fact that it will do so, illustrated in the examples cited from Col. EVEREST and others. What hope can there be that the effects of such irregularities can be eliminated by an investigation which, however admirable in principle and however ably wrought out, rests on a comparison of only forty latitudes? Not a single geodetic measurement has yet been made in all the immense expanse of northern and eastern Asia, of northern and central Africa, or of Australia and the Australasian archipelago. Nor, except in the small Peruvian arc, and the still smaller Pennsylvanian, which latter does not count, has the great American continent made any contribution to the solution of the difficult problem under consideration. When we consider, therefore, that the introduction of minute corrections, amounting only to small fractions of seconds, into only a part of the data employed in Captain CLARKE'S equations, suffices to modify the resulting dimensions of the earth

to such an extent as to produce, as we have seen, a very sensible change in the calculated value of the error of the metre, I think that the assertion just now made will be admitted to be perfectly well founded, *i.e.*, that if the length given originally to the metre had been exactly the ten-millionth part of the Paris meridian, this result would have been neither more nor less than a miracle. I may further add that, even if the metre had been quite correct, its authors could not have known it to be so, and we should not know it to be so now. When measurements shall have been made in those vast regions just mentioned, which have not yet been attacked by the geodesists, and when, instead of forty latitudes, four thousand shall have been thrown into the hopper of Prof. HUXLEY'S mill (though I confess that in such a case I should not be envious of the miller's task), we shall get out an inevitably different and a very certainly more satisfactory grist than has yet been ground for us. In the meantime, we may as well take the metre as we find it, and not concern ourselves about this Protean and microscopic fraction of error, which has so long been thrown up to it as a reproach.

EVERY ASSUMED "NATURAL STANDARD" LIABLE TO THE SAME OBJECTION, WHICH IS THEREFORE NO OBJECTION AT ALL.

It is a little remarkable that the objectors who find the error of the metre to be so grave a blot upon its

character, should nevertheless agree in urging us to accept a standard derived from another natural dimension of the earth, equally invariable no doubt with the quadrant, but at the same time equally unmeasurable —the polar axis or the polar radius. This is a dimension of which the authorities give us as many different values as they give of the quadrant; and of which they are sure to give us a new one every time an addition is made, no matter how trivial, to the data from which it is deduced. The values fluctuate perhaps between narrower limits of variation; and if the ten-millionth part of the earth's polar axis or the earth's polar radius were our theoretic metre, the absolute error of our practical metre would be probably rather less in proportion to its length, than that of the metre now in use. But the error would be there none the less; for, as before, it would be nothing short of a miracle if it were not; and between two errors, both of them microscopic, and neither of them affecting any conceivable human interest, I see for my own part little to choose. If the advocates of the radius metre could come to the defenders of the quadrant metre, and say to them, "Here, you see our metre has no error at all, and yours has one," the case would be a strong one; but that does not seem to be the case. Since these things are so, why then, you may inquire, should we endeavor to fix our standard of length with reference to either axis or quadrant or any other dimension which we do not know, and which it is per-

fectly certain that we shall never be able exactly to ascertain? That, gentlemen, is a question which you may very well ask, but which I shall not attempt to answer. I accept the metre as it is, not because it is the ten-millionth part of the French quadrant (though, according to Captain CLARKE, it *is* the ten-millionth part of the quadrant passing through New York, within less than the ten-thousandth part of an inch), but because it is the actual base of an admirable system of weights and measures already in use among one hundred and sixty millions of people, rapidly growing in favor among those who have not yet adopted it, and destined in my belief to be sooner or later the system of all the world.

NO COERCIVE MEASURES DESIRED IN BEHALF OF THE METRIC SYSTEM.

But, gentlemen, I do not expect that this system will make its way in the world against the will of the people of the world. I do not expect that our people, and I do not desire that any people, shall be coerced into receiving it by the force of "imperial edicts" or by the terror of bayonets. What I do expect is, that they will sooner or later welcome it as one of the greatest of social blessings. What I do expect is, that they will one day become conscious of the many inconveniences to which they are subjected from the anomalous numerical relations which connect, or rather

we might say, disjoin, the several parts of their present absurd system; inconveniences which they have learned to endure without reflecting on their causes or suspecting that they were unnecessary in the nature of things; and that when fully at length awake to the slavery in which they live, they will burst its shackles, and rejoice in the deliverance which the metric system brings. This cannot take place, of course, until the people are thoroughly informed. There are influences, therefore, which are now only beginning to operate, which must first have their full course before the results I anticipate will make themselves manifest.

EDUCATIONAL INFLUENCES TO BE INVOKED.

The first and most important of these is the education of the young to a thorough understanding of this system, and a perfect familiarity with its practical applications. The metric system must be taught in all our schools. It ought of course to be taught there, as being the system actually in use among nearly or quite half the inhabitants of the civilized world already, and without any regard to the question whether it is to be ours or not. But it ought to be taught, too, with special reference to this question, in order that another generation may meet it and settle it intelligently. And I think I hazard nothing in saying, that when one generation shall have grown up, into whose minds this knowledge shall have entered along with

the first rudiments of their learning, the question will no longer have two sides.

CUSTOMS DUTIES TO BE LEVIED ON THE BASIS OF THE METRIC MEASURES AND WEIGHTS.

But, in the second place, the system should be practically illustrated before the eyes of our people, by being introduced into our custom-houses, and made the guide according to which duties are assessed and collected. This measure will disturb the habits of no one in the affairs of ordinary life. Importing and exporting merchants will interpose no objection to the change. On the contrary, they will welcome it as greatly diminishing the amount of computation which they are now compelled to make. It is, in fact, the complaint of Prof. PIAZZI SMYTH, that it was the pressure of the commercial class which came so near to making the metric system the exclusive system in England in 1868. Our tariff laws will require transformation; but that transformation may be made without in any manner disturbing their essential provisions: so that no trouble need arise from this cause. What it is here proposed to do is nothing more nor less than what was actually done, some thirty years ago, by all the members of the German Zoll-verein. And though the state of things produced by it there will be superseded on the first of January, next, by the extension of the metric system in full over all the

component states of the late North German confederation, if not over the entire German empire; yet it will still exist in Austria, and will continue to exist in that empire until she, too, shall adopt the same system for her domestic affairs likewise.

PUBLIC SURVEYS TO BE CONDUCTED IN ACCORDANCE WITH THE MEASURES OF THE METRIC SYSTEM.

By degrees our Federal government may introduce the metric weights and measures into our public surveys; such as the coast survey, the several boundary surveys, the geological, topographical, and land surveys of the territories, and the surveys of the lakes. In the published reports of these works, or at least in such of them as are intended for, or are likely to have, a large circulation among the people, it would be advantageous, and would familarize metric values to the popular apprehension, if dimensions, quantities, and weights should be expressed both in metric denominations and those of the existing system.

NAVAL AND MILITARY ESTABLISHMENTS REQUIRED TO USE THE SYSTEM.

The metric weights and measures may further be introduced into actual use in the navy yards and military posts maintained by the government in the different parts of our territory; and, finally, the busi-

ness of the post office department may be largely, if not wholly, conducted, so far as weights and measures are concerned, in metric denominations.

THESE MEASURES RECOMMENDED BY THE PARIS CONFERENCE OF 1867.

These are measures which were unanimously recommended by the international conference on weights, measures, and moneys, which was convened in Paris, in 1867, consisting of delegates appointed by the governments of twenty-two different nations, including, of those not using the metric system, Austria, Russia, Sweden, Norway, Denmark, Turkey, Great Britain, and the United States. To most of them, as it appears to me, there can be no reasonable objection, even on the part of those who have no admiration for the metric system themselves, and no faith in the prediction of its final prevalence. If nothing follows them, they can at least do no harm.

CONCLUSION.

I have occupied, gentlemen, a larger portion of your time than I intended, and larger, I fear, than will have seemed to you reasonable. The subject itself is a large one, and my interest in it is deep. I am so far from pretending to have exhausted it, that I feel that what I have said is but the merest skeleton of an argument. I wish to be indulged only in a single additional re-

mark, which shall be in regard to the able and comprehensive, and, at times, eloquent report of Mr. JOHN QUINCY ADAMS, which you have republished in the same volume with the report of your committee.

The original publication of that report, able and powerful as it is, and for the very reason that it is able and powerful, I esteem to have been a serious public misfortune. It effectually extinguished all hope of metrological reform in the United States for half a century. And yet Mr. ADAMS, decidedly as he discouraged any legislation, at least for the time being, and apparently for a very long time, looking toward the recognition of the metre in America ; darkly as he drew in the lines as he painted the picture of France writhing in the toils which the metric system had thrown round her ; and fondly as he lingered over that beautiful system of British weights and measures distinguished by the priceless property of a "uniformity of proportion" of which he laments that there remain to us only the ruins ; Mr. ADAMS, after all, was an admirer of the metric system to such an extent, that one is sometimes at a loss to decide whether he seems to love or to fear it most. In the midst of his doubts and his misgivings, he cannot refrain from occasionally enlarging upon its merits, in language strong enough to satisfy even the most enthusiastic of its advocates. And when for a moment he succeeds in forgetting France, and in shaking himself free from the embarrassing associations of the immediate present, he becomes

as it were inspired with a spirit of prophecy, under the influence of which he is oblivious of all difficulties, and glowingly anticipates that very approaching triumph which his own labors are destined so considerably to postpone. No words that I can use can add to the positiveness of assertion with which he predicts that final consummation to which I have declared to you to-day that I so confidently look forward. I cannot do better, therefore, in concluding these remarks, to which I thank you for having so indulgently listened, than to adopt his own language, and to express with him the conviction that, "If man upon earth be an improvable being, if that universal peace which was the object of a Saviour's mission, which is the desire of the philosopher, the longing of the philanthropist, the trembling hope of the Christian, is a blessing to which the futurity of mortal man has a claim of more than mortal promise; if the Spirit of Evil is, before the final consummation of things, to be cast down from his dominion over men, and bound in the chains of a thousand years, the foretaste here of man's eternal felicity; then this system of common instruments to accomplish all the changes of social and friendly commerce will furnish the links of sympathy between the inhabitants of the most distant regions; *the metre will surround the world in use as well as in multiplied extension;* and one language of weights and measures will be spoken from the equator to the poles."

APPENDICES.

APPENDIX A.

NOTE ON THE UNIFICATION OF MONEYS.

(REFERRED TO ON PAGE 24.)

The expediency, or rather, in fact the necessity, of treating independently and separately the difficult question of the unification of the monetary systems of the world, is made immediately evident when we consider that, though moneys are measures of value, their relations to the measures of material quantity are not fixed by any necessary law. In all systems of ordinary metrology, to settle the standard of length, settles the standards of capacity and weight as well; but it leaves the standard of money still unsettled, and permits most widely different views to be maintained on this point, with almost equal plausibility. There are besides, as mentioned in the foot note on page twenty-four, a number of considerations which specially complicate the monetary problem; and to postpone the simpler question of metrological reform until all these can be disposed of to the satisfaction of all nations, would be as unwise as it is unnecessary.

The popular impression is undoubtedly quite the reverse of this. It is an opinion easily taken up upon a *primâ facie* view of the subject, that the pound sterling of Great Britain, the dollar of the United States, and the franc of the French republic, might, by the simplest process of legislation in the world, be reduced to a regular geometrical series of values. Hence therefore it is probable that everybody, who knows anything about these important national money-units and the relations

in which they stand to each other, has often said to himself, in the language of one of the resolutions reported to the Convocation of the University of the State of New York, by their committee on weights, measures, and coinage, that "such changes should be made in the values of the franc, the dollar, and the English pound sterling, that five francs be exactly equal in value to one dollar, and five dollars exactly equal in value to one pound sterling." It was surely not an observation so little profound as this, that the convocation had a right to expect of their committee. Considered as a help toward the attainment of the desired uniformity of currencies, it rather reminds one of good Mrs. Nickleby's very practical suggestions to her embarrassed husband. "My dear Nicholas," said this excellent lady, "why don't you *do* something? Why don't you make some arrangement?"

The committee propose to the convocation to resolve that the discordance existing between the monetary systems of three great nations ought to disappear. But this is only what all the world resolved long ago; and therefore it has happened, that the sundry international conferences which have been called during the last fifteen years to consider this subject, have wasted no breath in axiomatic propositions and empty generalities, but have given all their collected strength to the study of the knotty problem, *how* this thing is to be done. To the solution of this problem, considered by the ablest publicists and profoundest financiers of all nations to be one of the most perplexing with which legislation has to grapple, the committee might surely have contributed something, had it been only in the way of making known the difficulties by which the question is embarrassed. This would have been better than, like Mrs. Nickleby, to recommend that the nations should "make some arrangement."

Without attempting to exhaust the subject, let us hint at a few of these embarrassments. The pound sterling, the dollar, and the franc are respectively units of the money of account

of the peoples of Great Britain, the United States, and France. The pound sterling is represented in currency by a gold coin, called a sovereign; the dollar, by a coin of either gold or silver, called also a dollar; and the franc, by a silver coin, bearing likewise the name franc; but a coin of five francs is struck either in gold or in silver. The British mint coins silver, but gold is the standard metal, and the silver coins are legal tenders only for small amounts. In France and the United States, gold and silver are both standard metals—or there exists legally what is called a double standard; hence all gold coins in either country, and all silver dollars in the United States, or silver five franc pieces in France, are legal tenders for all amounts. The theoretic basis of the French system of coinage is the silver franc (composed of nine parts of pure silver to one part of alloy), having the metric weight of five grammes. This coin, which is now no longer issued from the mint, and which has long since ceased to have a practical existence, was also a legal tender for any sums while it lasted. The present silver currency of France, with the exception of the silver five-franc piece, is a debased coinage, and is not legal tender except in small transactions. Similarly, the silver currency of the United States below the silver dollar, is, if not debased, at least degraded, by being diminished in weight, so that its nominal value is greater than its real value, and it is not a legal tender except for trifling sums. Now the reason why the silver legal tenders have disappeared from circulation in France and the United States, is explained as follows.

Since, to coins of determinate legal value, determinate weights must be assigned and permanently maintained, it follows that, where the double standard exists, the *relative* value of gold and silver must be fixed by law. But the relative value of these two metals is not fixed in the nature of things, any more than is that of any other two commodities. It varies with the varying supplies of these two metals respectively, and of the varying de-

mand for them, not only for the purposes of coinage, but also for the uses of luxury and of the arts. Accordingly, in the course of the last few centuries, it has widely fluctuated in Europe. About the middle of the thirteenth century, gold was worth in England only about ten times as much as the same weight of silver. A century later, the ratio stood as twelve and a half to one. The highest point it has ever attained appears, by the researches of E. B. ELLIOTT, Esq., Statistician to the United States Treasury Department, to have been fifteen and eighty-three one-hundredths to one. The same authority puts this ratio, now, at fifteen and thirty-eight one-hundredths to one. Now, the ratio between legal tender silver and legal tender gold is, in the United States, sixteen to one. And as a gold dollar will pay a debt as well as a silver dollar, while the gold dollar is really worth only fifteen and thirty-eight one-hundredths times its own weight of silver, and the silver dollar weighs *sixteen* times as much as the gold dollar, it is evidently for the interest of the holder of silver dollars to deprive them of their character as coins, by melting them up ; and to sell the resulting bullion for gold dollars. Hence the disappearance of our legal tender silver, and the degradation by law of our smaller silver currency to a degree which brings down the ratio so low as to fourteen and eighty-eight one-hundredths to one.

The French have fixed the ratio between these two metals at fifteen and five-tenths to one. This is nearer the present truth, but it is still sufficiently too high to allow the circulation of legal tender silver ; and, accordingly, the legal tender silver franc, which is the theoretic basis of the system (in the absence of which this system, considered as a metrical system, is completely fictitious), has ceased to be coined, and exists only in name.

Now, if the law in France which fixes the relative value of the two standard metals should be slightly changed, so as to make the ratio fifteen to one, it is obvious that the silver five-franc

pieces, of which many still exist, would immediately return to circulation, and would be in great demand; also, that the legal tender franc might again be safely coined, though possibly it might not be coined largely on account of the greater wear of small coins by abrasion. And from this time forward it is equally obvious that gold would begin to disappear.

The impossibility which is thus seen to exist, of maintaining two legal tender coinages of different metals side by side, would seem to most minds, at the first examination of the question, to be a quite conclusive reason against the adoption of the double standard. And yet it is on this very fact that some of the most eminent publicists of France have founded their strongest arguments in defence of a system so seemingly vicious. At the International Conference which was called in 1867, to consider questions of money, weights and measures, Mr. Wolowski urged that, when the legal ratio is fixed nearly at the mean actual ratio, the tendency, in case of fluctuations, to bring at one time one metal into demand, and at another time another, exerts a steadying effect upon values, and operates to retard these fluctuations, and to diminish their extent.

Now there is solid reason in the view thus taken ; and if the tendency spoken of were to be left undisturbed, it would certainly temper, if not entirely obviate, the undeniable evils attendant on the double standard. But, historically, it is certain that this tendency has never been left undisturbed; and there is therefore good reason to believe that it never will be. The fact has constantly been, that, so soon as one of the metals has begun to be crowded out of circulation, the attempt has been made to legislate it back by degrading or debasing the coinage in that metal. And thus the maintenance of the double standard, instead of maintaining the equilibrium of ratios, as imagined by Mr. Wolowski, operates as a constant temptation to the commission of the gravest of all possible errors of legislation in matters of finance.

But, obviously, we are in no condition to agree upon a common system of money for all the world, until we can, at least, agree first upon a common representative standard of money values. The French begin with a silver franc of determinate fineness and simple determinate metric weight. From this, by a numerical relation of values, entirely arbitrary and artificial, they deduce the weight of the one-franc theoretical, or of the five-franc piece actual, of gold of similar fineness; which weight is fifty thirty-first parts of one gramme—a quantity no longer simply metrical, nor expressible by a finite decimal. But this five-franc piece of gold, which is not metrical in weight, the Paris Conference of 1867 recommended to the world as the basis of an international coinage; making this recommendation in the same breath in which they recommended the universal adoption of the metric system of weights and measures.

It is manifest that the double standard cannot be maintained. But supposing the double standard abandoned, it does not follow that the single standard of *gold* will be immediately and universally accepted. Of nations recognizing but a single standard, some, like Holland, prefer silver to gold. It is notorious that the Oriental peoples, who have absorbed the silver dollar coinage of Spain, Mexico, and the United States, as fast as it could be produced, have always steadily refused the sovereigns and the eagles and the doubloons and the napoleons. Before we can proceed a step, therefore, toward the creation of an international monetary system, we must not only agree upon a single standard, but agree also what that standard shall be.

But such an agreement is by no means so simple a matter to reach as it seems. Notwithstanding that the drift of opinion among statesmen and authorities on finance is decidedly towards gold, the need of a coin which will be received by the people of China and Japan is one which must be met; while the metric nations of France, Belgium, Italy, and Switzerland, who are allied for the maintenance of a common monetary system, will

abandon very reluctantly, if at all, the alternative silver standard; since, in abolishing that, they must abolish at the same time the agreeable fiction which maintains their coinage in decimal relations with the metric system of weights and measures—one ideal napoleon of silver weighing exactly one hundred grammes, while one actual napoleon of gold weighs 6.4516129 + grammes, the decimal being without end.

But, supposing this difficulty to be somehow or other disposed of, we presently encounter another, usually quite overlooked in popular or conversational discussions of this subject—a difficulty which, nevertheless, is grave enough to require no small effort to remove it. It is well known that the precious metals, when in a state of purity, are too soft to be advantageously employed as the material for coinage. Their alloys offer greater resistance to abrasion, and therefore wear longer. On this account such alloys are preferred, for the uses of the mint, to the pure metals. But as the weight of pure metal (gold or silver) in a coin determines its value, so the total weight of any given coin must be increased in proportion as the metal of which it is composed is more largely alloyed. It is therefore obviously advisable to introduce as small an amount of base metal into the compound as practicable, consistently with the attainment of the desired hardness. But the question, what are the proportions which under a given value combine the maximum of durability with the minimum of weight, is one which, as a question of pure science, has not yet been solved. Accordingly, the statutory provisions established by different governments in regard to the standard fineness of their coins, are widely discordant. For coins of gold, the proportion of nine parts of the precious metal to one part of alloy has been adopted by our own country, and by France, Belgium, Italy, Switzerland, Prussia, Bavaria, and Spain. Austria employs the same for her gold crown and half-crown, and Holland for her double-William and its sub-multiples. But for her ducat and double-ducat, Holland employs an

alloy containing fifty-nine parts of pure gold to one of alloy; and Austria, for a coin of the same name, prescribes a fineness of seventy-one parts of pure gold out of seventy-two of total weight. This latter is also the proportion employed in the gold coins of Wurtemberg.

The standard of fineness in use in Great Britain, Portugal, Brazil, and Turkey, consists of eleven parts of pure gold to one of base metal; and that of Sweden, of thirty-nine parts of pure gold to one of the alloy. In other countries the standard falls below nine-tenths. In Denmark it is eight hundred and ninety-five one-thousandths; in Russia, eighty-eight one-hundredths; in Mexico it is different in different coins, being eight hundred and seventy-five one-thousandths in the piece of twenty pesos, and eight hundred and sixty-six one-thousandths in the doubloon; in Bolivia it is eighty-seven one-hundredths; in Ecuador, eight hundred and forty-four one thousandths; and so on, reaching in the Japanese cobang the extreme debasement represented by five hundred and seventy-two parts of pure gold to four hundred and twenty-eight of alloying metal.

Similar diversity of legislation is observable in regard to silver coins; but as to these there is a more general conformity to the standard of nine-tenths. Such is the fineness of the large silver coins of the United States, and of France, Belgium, Italy, Switzerland, Prussia, Bavaria, Wurtemberg, Baden, Hesse Darmstadt, Austria, and Spain; while England employs an alloy of thirty-seven fortieths; and Holland, one of nine hundred and forty-five one-thousandths. In other countries the standard is generally lower; and in most or all of those above named, the subsidiary silver coinage is materially less fine.

As the several German States named in the foregoing paragraphs are now members of the German empire, the diversities noticed among them will probably soon disappear. There appears to be everywhere a growing disposition to adopt the uniform standard of nine-tenths. But to change a standard of

this kind is by no means so simple a thing as it seems. Suppose, for instance, there happens to be already a vast existing coinage, circulating among a people who propose to make such a change. The modification of the standard changes the appearance of the coin to the eye (the color, in the case of gold) and changes also the weight, without, nevertheless, changing the value. Both these changes are disadvantageous to the freedom of circulation. In our own country, for example, differences of color between different coinages of eagles and double-eagles, arising out of the fact that, in the refining of the native gold, the metals naturally associated with this have not always been separated with equal thoroughness (though the residual impurity has always been carefully determined and allowed for as part of the alloy), have been regarded by the director of our mint, Gov. POLLOCK, to be sufficiently prejudicial to the character of the coin to call for notice in his communications to the Treasury Department, and to require measures to be taken for their correction. But the difference in the *weight* of coins produced by varying the proportions of the alloy, is the occasion of a much more serious disadvantage. To count out coined money in large sums is a very time-consuming operation. In minting establishments and in great banks of deposit, there may be, and in the former case there usually will be, found mechanical contrivances for counting by hundreds of pieces at once (available, however, only when the coins are all of the same denomination); but it is not to be supposed that tradesmen, merchants, or even bankers generally can be provided with such conveniences. Coins, when transferred from hand to hand in large masses, are therefore rarely counted. They are simply weighed in bulk; and the weight, when the composition is uniform, is an infallible indication of the value. But this cannot be the case if the mass consist of mixed coins, some of them of one degree of fineness and some of another. Hence, whenever the standard of fineness is changed by law, it becomes desirable and even almost necessary, to with-

draw from circulation all the legal tender coinage in the same metal already in existence. This consideration is one of no trifling importance to a people who, like the British people, have no less than eighty millions of pounds sterling—say four hundred millions of dollars—in the form of gold sovereigns and half sovereigns. This is the estimate of the existing British gold coinage, as made by the eminent statistician, Prof. JEVONS, in a communication made in 1868 to the Statistical Society of London, and corroborated by Mr. MILLER, of the Bank of England, who is quoted as authority to this effect by Dr. FARR, delegate from Great Britain to the International Statistical Congress, held at the Hague, in 1869, in a report made by him to that body. It may easily be conceived that Great Britain would bring herself reluctantly to the adoption of the standard of nine-tenths, even though convinced that it is a better standard than that which she employs at present. Her delegates to the International Conference of 1867 gave their assent to the proposition favoring the nine-tenths standard, though not concealing their preference for their own,* solely, as it would appear, because they saw no hope of a general agreement upon any other.

But let us suppose that we have got over the difficulty of the standard metal, and of the double or single standard, and also over any difficulty as to the standard of fineness; we find yet behind a difficulty far more troublesome. The visible representative of our unit of account is to be, we will say, a coin of gold of the fineness of nine-tenths; the question now arises, what shall be the *weight* of this coin? It is easy to see that this question may be so answered as to demonetize at once the entire metallic currency of the world; and that, if we are ever to have an universally accepted international coinage, it *must* be

* Report of the Master of the Mint, Sir THOMAS GRAHAM, and Mr. C. RIVERS WILSON, delegates to the International Monetary Conference, made Dec. 2, 1867, to the Lords Commissioners of the Treasury.

so answered as to produce, to some extent, and, it may be, to a large extent, an effect of this kind. To touch an interest of so vast magnitude as the coinage of the world, is a thing which, to be done safely, must be done cautiously. It is a low estimate, to place the value of the gold and silver coin now existing at twenty-five hundred millions of dollars. This is the estimate of Mr. McCulloch, in the article on the "Precious Metals," contributed by him to the *Encyclopedia Britannica*. But in this he attributes to Great Britain only from seventy to seventy-five millions sterling of coin in both gold and silver, taken together; while Professor Jevons and Mr. Miller, as we have seen, place the gold alone as high as eighty millions, while putting the silver coinage at fourteen millions: thus making a total of ninety-four millions.

The coinage of France Mr. McCulloch puts at from one hundred and thirty to one hundred and forty millions sterling. That of the rest of Europe, of North and South America, of Australia, of the Cape of Good Hope, and of Algeria united, he supposes may equal three hundred millions; so that, summing up all these several estimates, he would make out a grand total for the world, excluding Asia and all Africa excepting Algeria and the Cape, falling somewhere between four hundred and ninety and five hundred and ten millions—say in round numbers five hundred millions, which is the mean of the two, and is nearly equivalent to twenty-five hundred millions of dollars, as above.

From statements made by the Hon. Samuel B. Ruggles, the distinguished representative of the United States at the International Monetary Conference of 1867, in a written argument addressed to the conference, we should be justified in carrying the total much higher, perhaps to not less than three thousand millions of dollars. Mr. Ruggles stated that the mint of the United States had coined, up to that time, eight hundred and forty-five millions of dollars, in all; and that, of this sum, probably three hundred millions still remained in the country. He took the

estimates of De Parieu for France, Belgium, and Italy, at fourteen hundred millions; and allowing four hundred millions more for the remaining countries of continental Europe, he made the total for the continent entire, eighteen hundred millions. This last assumption is considerably more than justified by the estimates of McCulloch, since the latter authority puts down Russia alone for two hundred and seventy millions of dollars; which would leave, comparing this statement with that of Mr. Ruggles, only one hundred and thirty millions for Spain, Portugal, Holland, Denmark, Sweden, Norway, Switzerland, Austria, Turkey, and all Germany.

Taking, however, the eighteen hundred millions of this report of Mr. Ruggles as the total for continental Europe, and his three hundred millions as a proper estimate for the United States, with the four hundred millions of McCulloch for Great Britain, we shall have the twenty-five hundred millions complete, without going any further, or making any allowance for Mexico, British America, the West India Islands, Central America, South America, Australia, the Cape, Algeria, or Egypt. Considering that we have, among these, some of the principal gold producing and silver producing states of the world, it is a small estimate to suppose that they have among them the five hundred millions necessary to bring up this result to the round total of three thousand millions, named above. It must further be noted that no account is taken in either of these estimates of British India, or of China and Japan, which latter countries have been large recipients of the silver coin of Europe and America.

A more recent and very carefully considered estimate by Mr. Ruggles, embraced in his supplementary report, as delegate to the International Monetary Conference above mentioned, made April 8, 1870, to the Secretary of State of the United States, reduces this total to twenty-five hundred and fifty millions of dollars. As this estimate classifies the nations in groups as using the gold franc, the gold dollar, the gold sovereign, or

other coins of gold, it has an important practical interest in connection with the question of the unification of coinage. Mr. RUGGLES says:

"According to the estimates of political economists and bankers in Europe and the United States, believed to be reliable, the amount of gold coin now outstanding, in the various parts of Europe and America, is in round numbers:*

"I. In France, Belgium, Switzerland, Italy and Pontifical States, using the gold franc	$1,250,000,000
"II. In Austria, Spain, Sweden, Greece and Roumania, agreeing to use the franc.....	200,000,000
	$1,450,000,000
"III. In the United Kingdom using the sovereign.....	450,000,000
"VI. In the United States using the gold dollar.....	200,000,000
"V. In Germany, (North and South,) Netherlands, Denmark, Norway, Portugal, Russia and Turkey using other gold coins, all differing in value.....	300,000,000
	$2,400,000,000
"VI. In Canada, Mexico, Central America and South America using sovereigns, dollars, doubloons and various other gold coins..	150,000,000
	$2,550,000,000

* To make the exhibit complete, the following statement of the population and foreign commerce of the several groups of nations above given, should be added. It is derived also from the report of Mr. RUGGLES referred to.

	Population.	*Foreign Commerce.*†	*Gold Coin Outstanding.*
Using the franc.....	135,700,000	$1,648,000,000	$1,250,000,000
" pound.....	30,400,000	1,251,500,000	450,000,000
" dollar.....	38,555,983	438,500,000	200,000,000
" other gold coins...	135,500,000	852,000,000	300,000,000
" various coins.....	373,600,000	240,000,000	150,000,000

† Deducting duplications: in the full statistics of commerce, the same values appear twice.

It is evident from the foregoing, that great exactness is not yet attainable in the statistics of this subject. What can only be exactly known are the issues of the several mints. The history of those issues after they have passed into private hands, is not easily traced. Dr. FARR, in his valuable and elaborate report, above spoken of, to the Statistical Congress at the Hague, gives the methods and results of some interesting investigations concerning the average life of the British gold sovereign. Such inquiries throw much light upon the subject; but as the conditions of the life of coin are not necessarily the same in all countries, they must be prosecuted longer and more generally before they can be regarded as having acquired for this branch of statistics the character of an exact science.

Yet, whatever may be the degree of confidence or of doubt with which we speak in definite terms of the immense values actually existing in the world in the shape of coin, we can entertain no doubt at all that these values are really immense. And hence we perceive the serious gravity of the interests liable to be affected by the answer which may be given to the question, what shall be the weight of the visible representative of the international monetary unit? The persons who settle great questions of international coinage over the breakfast-table, or block out schemes for the reconciliation of discordant monetary systems in their moments of leisure or recreation, frequently express impatience of the sluggishness with which the world advances in a path so plain; and account, perhaps, for the phenomenon, on theories of the indifference or unskilfulness of diplomatists, or of the obstinacy of ministers. It rarely occurs to such persons to consider that diplomatists and ministers have, in fact, as great an interest in the happy solution of this important question as they; and are, perhaps, making progress as rapidly as they themselves would be likely to do, if they had the management of the whole business in their own hands. The grave fact, which has rendered unavailing the labors of all the

international monetary conferences of the last fifteen years, has been, that no common currency can be adopted by the nations, without condemning the entire coinage of one or another of them, and perhaps of several, to the melting pot. This consideration, and the consequences it involves affecting the liquidation of existing debts in coin of altered weight, determined the State Department of our own country to propose to the governments of Europe, about a year ago, a plan for giving to the gold coin of all nations an international circulation, without essentially altering their present actual weights or values. The plan here referred to consists in assuming a common unit of value so small, that the most important gold coins of all nations may be made, by slight changes, exact multiples of this. And in order to avoid any embarrassment from diversity in the standards of fineness, it also proposed to make the unit a definite weight, not of alloyed gold, but of *pure gold*. The unit weight proposed was one decigramme. The value of one decigramme of pure gold is very nearly six and two-thirds cents. The gold dollar contains of such pure metal fifteen decigrammes and a little more than forty-six one-thousandths of a decigramme. By dropping the small fraction in excess of fifteen decigrammes, the value of which is but thirty-one one-hundredths of a cent, the dollar becomes just fifteen times the unit; and the half-eagle, seventy-five times the unit. The sovereign, by a similar slight adjustment, becomes equal to seventy-three times the unit; the napoleon, to fifty-eight times the unit; the double ducat of Austria, to sixty-nine times the unit; and so on with respect to other coins.

The merit of this scheme, and it is not a small one, is, that it would bring the monetary units of the different nations into relations of commensurability, without impairing the usefulness for the purposes of money of the coin actually in existence. The disadvantages attending it are, that the ratios of commensurability which it establishes are lacking in the simplicity which is the indispensable condition of practical usefulness; and that the

diversity of alloys employed in the coins of the different nations must always prevent any national coinage from securing a free international circulation. This scheme, therefore, though simple and at first view seemingly feasible, does not appear, upon mature consideration, to offer an adequate solution of the difficult problem before us.'

Other propositions, looking to the same end, have been :

1. To adopt as a unit of account the value of some convenient coin now actually existing, with its corresponding weight in gold ; a proposition which is equivalent to requiring that all the systems of coinage now in use, except one, shall be abandoned ; and that this one, from being simply national, shall become international and universal.

2. To adopt a value represented by no coin at present, but of which the representative in gold shall be the unit base of such system of weights as may be adopted for international use (say the metric system), or shall bear a decimal relation to that base.

3. To adopt a value of which the representative in gold shall be in simple, though not necessarily in decimal, relation to the base unit of the system of weights ; and which shall itself be such that the coinage of the principal commercial nations may be conformed to it without very large changes of weight.

In considering the first of these propositions, no existing coins will be likely to suggest themselves as possessing claims worth attention, except the gold piece of five francs, the gold dollar, or the gold sovereign. The sovereign, out of England, is likely to find no support ; being elsewhere regarded generally as representing too large a value to be conveniently employed as a unit of account. In fact, the British commissioners to the international conferences have themselves proposed, rather, a determinate part of the pound sterling—as an eight-shilling piece, for example—than the pound sterling itself. The piece of five francs, with its present actual weight, and actual fineness of

nine-tenths, was recommended as the international unit by the monetary conference of all nations, held at Paris in 1867; and it is now warmly advocated by men eminent as statesmen, statisticians, and publicists, in the United States and on the continent of Europe. The representatives of France in that conference went even so far, in the ardor of their desire to win over other nations to a measure so flattering to their country, as to consent to the abolition of the double standard and the adoption of the gold standard only; although by so doing they would be compelled to sever the connection between their monetary system and their system of weights and measures; thus presenting to the world the remarkable spectacle of the first of metric nations recommending and advocating a non-metric coinage.

It is not, however, to any sentiment of a merely selfish nature, that this important concession on the part of these gentlemen is to be ascribed. The result must rather be regarded as a reluctant sacrifice of a cherished ideal, to what seemed to them, at least, the constraining force of accomplished facts. Some idea of the weight of the considerations which led them to their conclusion, may be gathered from the following summary of the debate in the conference, given by Mr. Ruggles in his supplementary report of April 8, 1870.

"The debates were systematically conducted by means of questions methodically and carefully arranged. They were commenced by the discussion much at length of the following preliminary and comprehensive question:

"'By what means is it most easy to realize monetary unification: whether by the creation of a system altogether new and independent of existing systems; or by the mutual coördination of existing systems, taking into account the scientific advantages of certain types and the number of the populations which have already adopted them?'

"On this cardinal question, the debate was prolonged and important, in which the delegates from many of the nations

took part. It was commenced by M. Mees, delegate from the Netherlands and President of the Netherlands Bank, who 'declared that if he could admit the immediate realization of the unification of coinage, he would give the preference to the first of the two alternatives. In this case, in effect, the creation of a new system, avoiding all national susceptibilities, would seem to him the best way to obtain the end. But it does not seem possible to him, that complete uniformity can be speedily attained, and therefore he considers the second alternative as being alone of a nature to produce actual practical results.'

"The Count d'Avila, delegate from Portugal, and recently its Minister of Finance, maintained that 'if the different States found themselves obliged by the establishment of a system altogether novel to change simultaneously their monetary regulations, the difficulties of the attempt would be multiplied in such manner that they would become insurmountable.' He further deemed it 'essential that an agreement should take place between England, France, and the United States,' that it 'would sooner or later rally also the other countries,' and that the 'example would have a decisive effect.' He declared himself ready to vote for a single gold standard, the reduction of the pound sterling to twenty-five francs, and the American dollar to five francs, with the gold coin of five francs as the monetary unit.

"The delegate from Austria, the late Baron de Hock, favorably known by his works on finance, concurred in the opinion expressed as to the impossibility of securing the acceptance of an entirely new system, and completely breaking up inveterate habits. 'In Germany,' said he, 'we find a striking example: there was a wish to introduce into the German States a coin not correspondent with any existing types. Although it was the most rational and accorded *perfectly with the metric system*, it could not find its way into calculations. The *gold crown* only passed from the mint into the melting pots of the goldsmiths.

It is only as expressed in the second sentence of the first question, by the mutual coördination of existing legislation, by taking into account the scientific advantages of certain types, and the number of the populations which have already adopted them, that a solution may be found.' He added that gold, 'which has spread in such considerable amounts through the European markets during the last twenty years, would be the most convenient agent for a universal monetary circulation.'

"M. Feer Herzog, one of the two delegates from Switzerland and familiar with its financial affairs, said that 'there is in France a school important because of the scientific authority of its adepts, which admits no other monetary unity than metric unity in round numbers, and proposes to take for the unit a weight of five grams of gold, nine-tenths fine,' (equivalent to $\$2.99\frac{09}{100}$ of the present money of the United States). 'This theoretic solution would be wanting in one essential quality, that of practicability. At the time we have arrived at, we cannot invent a monetary unit not in relation with any type actually existing. The franc itself had been compelled not to depart too far from the *livre tournois*, in order to make itself acceptable, and the gold crown, containing ten grams, has not been able to get into circulation in Germany because it is not adapted to the florin of Austria, nor the florin of Bavaria, nor the thaler of Prussia. By the very force of things,' said he, 'it is the napoleon [twenty francs], a foreign coin, which represents beyond all others the monetary circulation of gold in Germany.'

"The delegate from Russia, M. de Jacobi, Privy Councillor of the Crown, and member of the Imperial Academy of Sciences at St. Petersburg, highly distinguished in Europe not only in general physical science, but especially by his earnest and able advocacy of the merits of the metrical system, said that he 'adopted in full the ideas developed by M. Feer Herzog. He would have been glad that a relation should exist between coins and the systems of weights and measures, but in the double

view of science and practice, he saw no necessity for the establishing of such relations to the prejudice of other more important interests. He could not, therefore, regard as serious the reproach cast upon the coin of France, as having widened the breach in the French metric system.' He added that 'the creation of an entirely new coinage was so much the less opportune, that he could not let the occasion pass without noticing the agreement, perhaps accidental but almost complete, between the intrinsic value of the principal French coins and those of Russia. Thus the silver rouble coincides very nearly with four francs, the difference not exceeding the limits of the tolerance. In the same way the demi-imperial has a value only fifteen kopecks' (about eleven cents,) 'higher than the twenty franc gold piece.

"M. MEINECKE, the delegate from Prussia, thought it of prime necessity to adopt as the base of the new system, a system already recognized and reduced to practice. 'The difficulty,' said he, 'of adopting the gold standard, is much greater in Prussia than for any other country; but if the labors of the conference should aim at establishing the basis for a general monetary arrangement, Prussia would study with care the best mode of connecting herself with it.'

"On the other hand, Mr. STAS, one of the two delegates from Belgium, said that he 'would prefer the establishment of an entirely new monetary system, and that the conference assume as its mission, to settle principles and not expedients in practice. To follow the latter course would be to leave traces in the snow, not to engrave footprints in rock.' He also maintained that 'the creation of a system based on a standard of gold of five or ten grams would offer the immense advantage of having it more readily accepted by all nations, as it would avoid all national susceptibility. Doubtless the adoption of the new unit would require the general reminting of all coinage, but this recoinage would bring with it a definitive system sanctioned by science.'

He further asserted that, 'mathematically speaking, the kilogram cannot be divided into one hundred and fifty-five equal portions.'

"Mr. FEER HERZOG, replying to the remarks of Mr. STAS, said: 'there is nothing to hinder the definition of this napoleon by indicating the round number one hundred and fifty-five, which a kilogram includes, or rather it should be divided by the fractional number of grams which represent its weight, neglecting the decimals beyond the thousandths decimals, which practically are of no importance and have only an interest purely scientific. It is not indispensable to the goodness of coin that it should be metrically proportioned.'

"The delegate of the U. S. [Mr. RUGGLES] said it would be as impossible to abolish 'the expression of the dollar in the United States, as that of the sovereign in England, but that both might be retained in reducing their intrinsic values.' He said that 'two milliards ($2,000,000,000) in gold had been thrown into the money market since the discovery of the mines of Australia and California, and that it was certainly possible that the coinage of gold in the United States, in the next fifteen years may reach five milliards of francs ($1,000,000,000). In view of such a future, the American government would prefer to reduce its monetary unit at once.* But the United States in consenting to recoin its gold now in circulation, would expect France on her side, will consent to coin pieces of twenty-five francs, in which case monetary unification would at once assume a practical form.'"

"On closing the debate the question was taken by ayes and noes, on a roll-call of the nations, which resulted in an unanimous vote in favor of the second alternative in the question, in the following words, to wit:

"'It is more easy to realize monetary unification by mutual coördination of existing systems, taking into account the scientific advantages of certain types, and the numbers of the populations which have already adopted them.'"

* Approval of Department of State, in letter from Mr. SEWARD, June 21, 1867.

Subsequently, also, in a debate in the French Senate, on the expediency of immediately issuing, in furtherance of the plans of the conference, a gold coin of the value of twenty-five francs, the conflict between the perfection of theory and the possibilities of practice was brought very sharply out. The following is an abridged outline of the discussion, as given by Mr. RUGGLES.

"In this interesting and instructive debate, which occupies fourteen printed columns of the *Journal Officiel*, the comparative merits of the twenty-five franc coin and of a new coin of ten even grams (or a decagram), equivalent to thirty-one existing francs, were fully examined. The metrical merits of the proposed decagram coin had been urged on the twenty-first of January, by Mr. MICHEL CHEVALIER, in a general speech on the coinage of France, in which he had claimed for the decagram its perfect conformity to the 'logic of the metrical system.

"It is, however, specially noticeable that in the latter portion of his speech, Mr. CHEVALIER, who combines with his abstract philosophies, a large admixture of practical statesmanship, after stating these 'indications of logic,' very pertinently proceeds to ask and then to answer as follows :

"'Is it necessary to abandon ourselves absolutely and exclusively to logic? It is a question. Logic is a power ; but various conventional requirements *(convenances diverses)* may cause us to disregard it *(peuvent faire qu'on s'en écarte)*.

"'When, in order to conform wholly to logic, it is necessary to submit to considerable sacrifices, or to change the inveterate and cherished habits of peoples : and when even the triumph of logic is not to be followed by great advantages, we are allowed to hesitate. A wise administration may lay aside logic, and adopt combinations which from other points of view would be advantageous to the public interest.'

"The debate of the twenty-fifth of January was opened by Mr. LE VERRIER, the astronomer and *savan* measuring the outmost limits of planetary space by his skilful use of exact science. In

a powerful speech of wide range, he supported the plan of the twenty-five franc coin, as being practicable, in preference to that of the decagram, as being merely theoretical. He was followed by Mr. DUMAS, 'President of the Commission on Coins,' and as such, Director of the Mint, who stated that the recoinage required by the decagram, would cost seventy millions of francs, or fourteen millions of dollars. Mr. LE ROY DE SAINT-ARNAUD concurred with Mr. LE VERRIER, and held that 'the question could be resolved only in accordance with practical ideas. I admire science,' said he; 'I bow before the *savans;* but in questions of this nature, in which so many persons and interests are intermingled,' * * * 'I regret the excess of science, and fasten myself to the facts.' He was followed by General Marquis DE LAPLACE, who denounced the twenty-five franc coin as unmetrical and unnecessary, and urged among other objections, that it differed too little in size from the twenty-franc coin, and might tend to raise to twenty-five francs, the price of objects now selling at twenty.

"In closing the debate, the necessity for the immediate issue of the twenty-five franc coin, and indeed the whole plan of the Paris conference, were vindicated with signal ability by Mr. DE PARIEU, the universally acknowledged leader in Europe of the pending measure of monetary unification, and now president of the council of state in the new liberal ministry. Suffice it to say that in accordance with the form of proceeding peculiar to the body, the Senate 'passed to the order of the day,' thereby rejecting the proposition of the decagram, and virtually expressed their approbation of the twenty-five franc coin by leaving its issue to the proper minister charged with the coinage."

Since 1867 some progress has been made on the continent of Europe toward unification on the plan here proposed. The following further extract from the supplementary report of Mr. RUGGLES shows to what extent this is true:

"Up to the present time the recommendation of the conference in respect to the five franc gold unit (deferring the immediate consideration of the question of the single standard), has been adopted by nine of the nations of Europe, to wit: by France, Belgium, Switzerland, Italy, the Pontifical States, Spain, Greece, Roumania, and Sweden, having an aggregate population of one hundred million, three hundred thousand inhabitants.

"The preliminaries of a monetary treaty, providing for a coin assimilating the ten florins of Austria with the twenty-five francs of France, were signed by the authorized representatives of those two nations on the 31st of July, 1867. It contained a condition in respect to the double standard, not yet complied with by France, but specimen coins were struck in anticipation, in October, 1867, bearing the heads respectively of the Emperors of France and of Austria, with the reverse, inscribed '10 florins, 25 francs.' The adoption by France of the single standard, to which a school of political economists in that country still remains violently opposed, but which has been repeatedly and earnestly recommended in the reports of official investigations (*enquêtes*) by large commissions of imposing authority, will secure the completion and execution of the treaty by Austria, and thereby increase the number of European nations using the franc to ten, with an aggregate population of one hundred and thirty five million, four hundred thousand inhabitants.

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"The actual issue of the gold franc international coin has been commenced by some of the nations not included in the treaty of 1865. It is already in circulation in the flourishing principality of Roumania under the government of its present enlightened ruler, who has introduced in full the metrical weights, measures, and coins of France. His example, in all probability, will soon be followed by the Sultan of Turkey, who has manifested so strongly his wish to keep pace with the civilization of Europe.

"The assent of Spain to the franc system was given by the provisional government, in a formal decree, published at Madrid and Paris, soon after the expulsion of Queen Isabella.* A specimen of the new half franc silver coin now in possession of the undersigned, bears the well known 'pillars' with the ancient arms of Spain, encircled by the legend '400 *piezas en kilogramo*,' thus distinctly and arithmetically recording its assimilation with the 'franc,' two hundred of which are equiponderant with the French '*kilogramme*.'

"Among the northern European powers, the liberal and intelligent government of Sweden, so distinguished by its successful public works of intercommunication, has already issued the new gold pieces called '*Carolins*,' bearing the words '10 *francs*,' and now in common circulation in the countries on the Baltic. They are stamped with the 'image and superscription' of the Swedish monarch, CHARLES XV., lineally descended from BERNADOTTE and EUGÈNE BEAUHARNOIS, and now taking the lead in the civic march of monetary reform in the north of Europe. Under his influence and authority, Norway, which has a separate legislative body, will soon be united with Sweden in the gold franc system. His steady support of the legislative efforts of Mr. WALLENBERG, president of the Bank of Stockholm and one of the two delegates of Sweden and Norway in the Paris conference, has secured the coinage of a Swedish gold coin of twenty-five francs, to be issued as soon as similar pieces shall be put into circulation by the government of France."

These statements show a remarkable advance in public opinion since the fifth meeting of the International Statistical Congress, held at Berlin in 1863, at which time a measure so radical as the absolute unification of all currencies, seemed to the majority of that body altogether impracticable; so that a committee of the congress, while proposing to reduce the units of money "to a small number," deliberately recommended that the pound sterling, the dollar, the florin, and the franc, should all

* These assurances were renewed to Mr. DE PARIEU, on a visit by him to Madrid in 1871.

continue to be retained. Even at that early day, Mr. RUGGLES, who was present as the delegate to the Congress from the United States, protested against a conclusion so lame and impotent; and advocated universal unification on the basis of the gold unit of the value of five francs. He was thus the originator of the plan which, though defeated for the moment, was accepted later by the International Conference of 1867; and which has since been favored by the legislation of the continent to the extent above stated.

A proposition of this kind would, of course, not be made, unless the practical considerations in its favor were felt to outweigh any objections, derived from the beauty of congruity, or the exactions of a perfect theory. The arguments above cited therefore depend very much for their cogency upon the fact, that the gold coinage founded on the franc which is now actually in existence, constitutes nearly three-fifths of the total gold coinage of the world, and probably not less than two-thirds of that of Europe, including England. The unit of five francs, if adopted, will give at once an international character to this immense mass of coin, amounting to more than fourteen hundred millions of dollars—a fact of which the importance cannot be overestimated. It is, however, alleged in the report of the director of our mint, made in 1867, and also in statements by Baron EUGENE NOTHOMB in the Prussian Annals, that the gold coinage of France is below standard weight (though within the limits of tolerance) even on its first issue from the mints; and that it has even been designedly made so. The officers of the mint in Paris are said, however, to have denied this charge, and to have claimed that their coinage not only falls very little below the standard, but often exceeds it. Opinions must therefore be suspended; but if the statement be well founded, it must tend to diminish the weight of the argument derived from the magnitude of this coinage. To the people of Great Britain and of the United States, whose coins, if this unit were adopted, would require to be recoined, the latter being

more than three and a half per cent. in excess of weight, the plan will only become acceptable, when it shall have been clearly demonstrated to them that no other possibility exists of reconciling the monetary systems of the world.

The second of the expedients enumerated above as proposed for securing an international currency, viz., that of adopting the unit of weight, or one of its decimal derivatives, as the visible representative in gold of the unit of money, was suggested by Mr. Michel Chevalier, in the first instance, in the *Journal des Economistes*, for November, 1868, and afterwards advocated by him in the French Senate, as appears in the debate above cited. He proposed to take as a unit the *gramme* of standard gold, nine tenths fine, of which the value in our currency would differ but by an inappreciable fraction from sixty cents; or the dekagramme, which would be equivalent, with a correspondingly slight difference, to six dollars. Calling the coin of one gramme weight the *soldo*, the dollar would become, by an insignificant modification, one soldo and two thirds of a soldo; or six dollars would be equal to ten soldos. Our gold coins might therefore continue to serve as money without inconvenience, until such time as, having been worn out, they should be replaced by other coins in the form of soldos and multiples of the soldo. The napoleon, increased in weight by less than three fourths of one per cent., would be equal to six and a half soldos. The pound sterling, diminished in weight by one and two thirds per cent. would have the value of eight soldos. Thus the coinage of the three principal commercial nations of the world could still be made to subserve the purposes of money, till such time as a new coinage should be created to take its place. But these three nations, and all others adopting the system, would be obliged at once to change their unit of account, and with it their whole monetary system.

This scheme certainly has its advantages. It is strongly advocated by Dr. Farr, the able delegate from Great Britain to the

International Statistical Congress held at the Hague in 1869; though with a preference for the dekagramme, of the value of six dollars, or of one and a quarter (modified) sovereigns, as a unit, which he would name the *Victoria*. Five sovereigns on this plan would be equal to four Victorias.

The third of the methods suggested as offering a practicable solution of the problem under consideration, is exemplified in a proposition made in 1868 by Mr. GEORGE F. DUNNING, Superintendent at that time of the United States Assay Office in New York. This is to assume a unit having a weight of one gramme and sixty-two one-hundredths of a gramme of gold, nine-tenths fine; which corresponds, with a fractional difference entirely inappreciable, to twenty-five grains Troy. As a dollar weighs twenty-five grains and eight-tenths, this unit is but about three and one-tenth pêr cent. less, and it is proposed to call it still a dollar. The piece of five francs increased by forty-four one-hundredths of one per cent. becomes then equal to a dollar, and the sovereign diminished in the same proportion becomes the equivalent of the half eagle. This scheme has simple relations to the grain weight; but this recommendation is likely to lose its force with the prospective probable abandonment of the use of that weight altogether. The change which it proposes in the weight of the French coin, though not large, is in a direction unfavorable to the preservation of that coin long in use, if, as affirmed, the coinage is already too light; and it diminishes materially the value of our dollar without any corresponding advantage, which would not be gained by making it equal at once to the piece of five francs.

Another proposition founded upon the same principle, but recommended by a simpler relation to the metric system of weights, and a close approach in the unit proposed to the value of the American dollar, was presented in a petition to Congress from the American Statistical Association in 1867, and was laid before the American Association for the Advancement of Science

at its meeting of 1868 in Chicago, by Mr. E. B. ELLIOTT, of the United States Treasury, with whom it originated. This consists in making the dollar of such weight of standard gold as to contain one gramme and a half of the pure metal. The proposed alloy being one part in ten, it follows that the total weight of the dollar will be one gramme and two thirds; or employing the word *tergramme* to signify one third of a gramme, the weight of the dollar will be five tergrammes.

The division by three is justified, and even recommended, by the consideration that the presence of an alloy in the metal of coinage precludes the possibility of a strict adherence to the decimal scale. As it is probable that the fineness of nine-tenths will ultimately be universally preferred to any other, it will follow that ten parts of the alloyed metal will contain nine of the pure metal; which latter is only accounted to have value. And the simple divisor of nine is three.

This unit is less in value than the American dollar by a little more than three-tenths of one per cent.; a difference which is below the limit fixed by law for the tolerance of variations in weight, in the half eagle and inferior coins; so that the existing coinage of the United States would not be displaced by it. Its adoption in England would require an increase of weight of two and forty-three one-hundredths per cent. in the sovereign; and its introduction into France would necessitate a change in the napoleon in the same direction, to the extent of three and thirty-three one-hundredths per cent. Affecting, therefore, so seriously a very large proportion of the gold coinage of the world, this unit is likely to make its way but slowly, if at all. It is, nevertheless a more convenient unit of account than the pound sterling or the franc; it is simply related to the metric system of weights, which bids fair to become in due time universal; it is very nearly the equivalent of the Spanish dollar, so extensively employed in the commerce of the far east; it is an exact submultiple of the triple crown of the German Muntzverein;* and it

* This coin has practically disappeared from circulation.

is not so largely discordant with the coinage systems of England and France even, as to exclude the coins of those countries from circulation; though, till replaced by others, such coins might circulate at a discount.

In the notice which has here been taken of the several plans, which up to this time have been seriously advocated, for the unification of the monetary systems of the world, it has not been intended to indicate a preference for one of these rather than for another; nor even to assume that the possibilities in the case have been exhausted, or that a better plan than any one of them may not yet be proposed. The object in view has been simply to point out the peculiar difficulties which surround the subject, and to illustrate their magnitude; so that the propriety of dealing separately with the question of weights and measures may not seem doubtful.

To the plan of unification which rests on the French gold piece of five francs as its basis, the nations parties to the monetary treaty of December 23, 1865, including France, Belgium, Switzerland, and Italy are already prepared to assent. These nations have, in fact, only to abolish the double standard, and they have the system already The treaty referred to establishes for the parties to it a common system of coinage, to be maintained until January 1, 1880, if not sooner repealed. Spain, Sweden, Austria and Greece have exhibited a willingness to accept the same system; and Roumania has put it into practice.

The system of which the basis is the five tergramme coin of gold, of the fineness of nine-tenths, exists, as we have seen, practically, in the United States, at the present time. An important and rather unexpected encouragement has been afforded to the advocates of this scheme, during the current year, by the action of the government of the Japanese Empire. Sometime during the year 1870, the Master of the Mint of that Empire was deputed as a commissioner to visit Europe and the United States, with instructions to inquire into the systems of currency and

coinage prevailing among different peoples, in the design to effect a complete remodelling of the coinage of Japan. Commissioner Ito, after having fully informed himself of the diversity of views entertained by the prominent authorities on the subject in the countries visited by him, returned at length prepared to recommend, first, an entire departure from the traditions of the East as to a standard metal, by discarding the silver standard, and adopting the standard of gold only; and secondly, the adoption, as the unit basis of the new system, of a gold coin of the weight of one gramme and two-thirds, of the fineness of nine-tenths. The views of the Commissioner were approved; and a decree of the empire, which was promptly issued in conformity with them, provides for the stamping of gold coins of the several values, one *yen*, two yens, five yens, ten yens, and twenty yens—the yen being the name given to the unit-base or gold dollar. This coinage is made the only legal tender in the empire; except for small payments, which may be made in fractional coins of a subsidiary silver currency; and except also for transactions in the open ports, for which a silver one-yen, the equivalent of the Spanish dollar, continues to be coined, and is made legal tender for all sums.

This remarkable action, which illustrates in a striking manner the energy, the independence, and the freedom from prejudice, with which the sagacious rulers of the Japanese islands are seeking to improve the social, political, and material condition of their people, is possibly destined to have a larger influence on the ultimate settlement of the question of an international coinage than immediately appears. Should the example of Japan be followed by the neighboring and more populous empire of China, the demand of Oriental commerce may hereafter be for gold dollars instead of for silver; and this demand may decide the question what precise weight can be most advantageously given to the gold coins of Europe and of America.

The latest incident of importance which has occurred in the

political world, affecting the question of monetary unification, is one which rather increases than diminishes the difficulties surrounding this question; and one which we are therefore compelled to regard as a serious misfortune. During the closing months of the year 1871, Germany has permitted to pass unimproved, or rather has put to a very bad use, an opportunity such as can rarely be presented to a people for securing a great public benefit—an opportunity which she might have improved in such a manner as to settle decisively, at least for the continent of Europe, the question of an international coinage. While these lines are in writing, intelligence is received of the adoption of a monetary gold unit for the empire, upon a new basis called the *mark*, supposed to be equivalent in present value to one third of a Prussian silver *thaler*. The principal coin of this system is to contain twenty marks of gold, nine-tenths fine, and to have the weight of seven thousand, nine hundred and sixty-five milligrammes:—with the value, in the currency of the United States, of 4.76426 dollars.* This coin not being commensurable in weight or in value with either the franc, the dollar, or the sovereign, serves only to embarrass still further a problem already sufficiently difficult; and its introduction must have the effect to postpone indefinitely, for central Europe at least, the enjoyment of the great blessing of an uniform international currency, of which the prospect seemed recently so promising.

The heavy discouragement which this untoward action has brought with it to the cause of uniformity is, however, measurably relieved by some attendant and partially compensating advantages. If Germany has failed to grasp the favorable occasion for reconciling the conflicting monetary systems of Europe,

* The law provides for the minting of two gold coins; a piece of ten marks, and a piece of twenty marks. One hundred and thirty-nine and a half ten-mark pieces, or sixty-nine and three-quarters twenty-mark pieces are to be made from one German pound (five hundred grammes) of fine gold. A mark has the value of 23.8213 cents of the currency of the United States.

she has nevertheless brought order out of the confusion of her own. Henceforth, in reference to this matter, she contributes but a single element instead of many to the general discord; and permits us to say that the number of the inharmonious elements which, in studying the question of unification, we are compelled to consider, is practically reduced to these four—the mark, the franc, the pound sterling and the dollar. The relations which these bear to each other, as presented in the weights and values of their characteristic gold coins most nearly approximate, are given here—the weights being expressed in grammes and milligrammes, and the values in the currency of the United States:

Country. Coin.	Weight. Pure gold.	Weight. Standard gold.	Value.
Germany, 20-mark piece.....	7.168	7.965	$4.76.4
France, 25-franc piece (proposed)	7.258	8.065	4.82.4
Great Britain, Sovereign.....	7.322	8.136*	4.86.5
United States, Half Eagle.....	7.523	8.359	5.00.0

In this exhibit we have the whole case immediately under the eye. Till Germany intervened, the widest range of difference between the representative coins of the systems which it seemed most important to reconcile, was less than eighteen cents. She has extended it to nearly twenty-four. If the hope of an early and general unification seemed doubtful before, it must now be pronounced little better than desperate.

Yet it by no means becomes the friends of monetary reform on this account to fold their arms in discouragement. The very hopelessness of the case in the aspect here presented, imposes upon the four great powers above named, the moral obligation to lend their most serious attention to every alternative possibility of relief which may be suggested; and, in the actual state of things it is eminently well worth their consideration, whether present effort should not be directed

* Reduced to fineness of nine-tenths; present weight, eleven-twelfths fine, 7.988 grammes.

toward the creation of a coinage for international use upon a plan entirely independent of all local and purely national systems. Such an international coinage, though not in strictly commensurable relations with the coins now actually in use, would be productive of the great benefit of immensely simplifying commercial exchanges, and of providing travellers with a currency everywhere invariable in value. The advantages which its introduction would bring with it, are to some extent even now actually enjoyed throughout a large part of Europe, in consequence of the extended circulation which the gold napoleon has secured beyond the limits of the French territory. This coin is in fact international with the nations parties to the monetary treaty of December, 1865; and it is to this fact, no doubt, that it owes much of its popularity elsewhere. But though it circulates freely all over Germany, Austria, Holland, Denmark, and Sweden, it circulates only by toleration, and because of its great convenience; and is not a legal tender for payments of any amount, in any of those countries.

The international coinage here suggested will command, if established, an immediate circulation among all the peoples who shall unite in its creation; and will bring with it greater advantages than have attended the continental circulation of the napoleon. The existence of such a coinage will moreover keep constantly before the minds of all those who use it, the desirability of a currency which shall be not only international but everywhere uniform and identical. Thus the proposed coinage may become a powerful instrumentality in promoting the attainment of the object for which it seems at first to be only designed as a substitute—the ultimate complete unification of the monetary systems of the world.

An international coinage devised without reference to systems actually existing, and controlled in its principles by no considerations of what may be their discordances or resemblances, may be moreover constructed on a strictly scientific plan; and thus,

when time shall have familiarized the nations with its values and its visible forms, it may happen that, without violence, and by the spontaneous action of peoples themselves, diversity may silently give place to uniformity, and a better system than any which present legislation could create, may ultimately prevail throughout the world.

NOTES SUPPLEMENTARY.

1.—*Effect upon existing Contracts of a Change in the Legal Weight of Coins.*

Since committing the foregoing pages to the press, it is felt that sufficient prominence has not been given to the thought, cursorily suggested on page one hundred and thirty-one, that every change, small or great, introduced into the weight of legal tender coins, while the same coins continue to be unchanged in nominal value, imposes upon the government making it, the most stringent obligation, in honor and in morals, to provide for the full and exact fulfilment of all outstanding pecuniary engagements in the sense in which they were understood at the time they were contracted. From this obligation there is no possibility of escape. The public opinion of the world, to which in this age even monarchs must defer, will not suffer that, in the light of the nineteenth century, governments shall presume, on any pretext whatever, to imitate practices such as those to which unscrupulous despots were accustomed to resort in ruder times, that they might wring from the hand of honest industry its hard earned wages. There is one thing that is more valuable than national wealth or national power, and that is national honor; and it would be better to endure, to the end of time, all the evils and disadvantages with which the diversity and incongruity of existing monetary systems embarrass intercourse and encumber commerce, or even to go back to the rude iron currency of the Spartans, than to possess ourselves of the most perfect system that science can devise, through the operation of a legalized injustice. There can be little doubt that it was the gravity of these considerations which determined the government of the United States to make to the governments of Europe the proposition mentioned on the page above referred to; the effect of which would be, in case of its acceptance by those governments, to acquire to some extent for existing coinages the character of an international coinage, by making the values of their principal coins commensurable.

This plan, if adopted, owing to the minuteness of the changes which it demands, would simplify the legislation required for the introduction of an international coinage, and would secure the people, whom such legislation affects, against the inconvenience arising from the necessity of discharging their pecuniary liabilities in a currency differing from that which existed at the time when those liabilities were incurred.

2.—*The New System of Coinage of the Japanese Empire.*

In addition to the statements made on page 147, the following particulars may inte[illegible] The fineness of the subsidiary silver coinage is eight-tenths; and the ratio in valu[illegible] of the silver in this to gold is 1:13½. This coinage is legal tender to the amount of ten yen (dollars). In the silver one-yen coin for the open ports, the fineness is nine-tenths; and the ratio 1:16.173. (The gold one-yen contains 1.5 grammes of pure gold, and the [illegible] ver one-yen, 24.260726 grammes of pure silver.)

The gold coins are as follows: one yen, two yen, five yen, ten yen, and twenty yen. These are all legal tender for all payments, to any amount.

The rules relating to the silver one-yen are peculiar, and are as follows:

"For the sake of rendering facility to foreign commerce at those ports open to foreign[illegible], and in accordance with the requirements of the traders, both foreign and Japanese, the government will coin the silver one-yen and make it useful only for foreign comm[illegible]rce. This silver one-yen will be the legal tender in payment of local taxes and of import and export duties. It will also be the legal tender in any commercial transaction in the open ports. The said silver one-yen will, however, not be the legal tender in any other place [illegible]n the said open ports, and shall not be used for the payment of internal revenue of any kind, nor will it be lawful currency in the interior: but by mutual agreement any pe[illegible]son or persons may use it to any amount throughout Japan.

"In the payment of the import and export duties, the comparative rate of the gold yen to the silver one-yen will be as follows: thus, one hundred silver one-yen shall for the present be equivalent to one hundred and one gold yen."

The world will wait with interest for the result of this curious experiment. It m[illegible]ed hardly have been provided that the silver one-yen shall not be legal tender in the i[illegible]e rior. The probabilities are that it will never be seen there; and it is furthermore pro[illegible]ble that, so long as the legal relation between the silver one-yen and the gold yen remains as provided in the last paragraph foregoing, all the silver one-yen coins t[illegible] can be produced will be promptly bought up and exported as fast as they are issued fr[illegible] the mint.

APPENDIX B.

NOTE 1.—ON MEASURES OF CAPACITY, AND THE WEIGHT OF A GIVEN VOLUME OF WATER.

(REFERRED TO ON PAGE 39.)

A measure of capacity is, theoretically, a certain defined volume expressible in cubic units, integral or fractional, derived from some invariable linear measure. In theory, therefore, the measure of capacity is the same under all conditions. But, in practice, the capacity measure, being a vessel of metal, wood, or other material subject to expansion and contraction with variations of temperature, can correspond strictly with the theoretic measure only at some particular temperature.

In the United States the standard temperature is that at which the density of pure water is maximum. This is stated by Mr. F. R. HASSLER, by whom, as Chief of the Bureau of Weights and Measures, the experimental investigations were conducted which resulted in fixing the methods of adjusting the measures of capacity, in a report made by him, Jan. 27, 1832, as being true at 39°.83 * of the thermometer of Fahrenheit. The capacity of the bushel was, at the same time, fixed at 2150.42 cubic inches, which is the capacity of the old Winchester bushel of England; and that of the gallon, at 231 cubic inches, corresponding to the British wine gallon. But, inasmuch as the British standard temperature is 62° F., the Winchester bushel

* In his report of 1842, ten years later, Mr. HASSLER tacitly admits that this temperature is too high, by speaking of 39° F., as the temperature of maximum density. PLAYFAIR and JOULE make it 3°.945 C. = 39°.101 F.

of England and the Winchester bushel of the United States are equal to each other neither at 39°.83 F., nor at 62° F., nor at any other common temperature. In point of fact, the British Winchester bushel, when made of brass, contains, according to Mr. HASSLER, only 2148.9 cubic inches at the temperature adopted as standard in the United States; falling short of ours by one cubic inch and fifty-two one hundredths; while our exceeds the British by the same amount, at the temperature according to which the standards of Great Britain are adjusted.

To construct a measure of any description, whether of length or of capacity, or of weight, in exact conformity with a standard previously imposed, is a practical problem of extreme delicacy and difficulty. The verification of capacity measures is moreover attended with the special disadvantage, that the interiors of vessels cannot be subjected to microscopic measurement, with the same facility as the external contours of solids. Capacity measures designed to serve as standards are therefore verified by an indirect process, which consists in determining, by means of the balance, what quantity of pure water of known temperature they are capable of containing.* But in order that this method may be worthy of reliance, it is necessary first that the absolute weight of a given volume of water should be ascertained with the utmost exactness; and this not only at a given temperature, but at every temperature within a pretty wide range; since the rate of expansion of water with increasing temperature from the point of its maximum density, is governed by no obvious law. To the determination, therefore, of the

* During the process of weighing, the measure is closed by means of a plate of truly plane ground glass, the top or rim being correspondingly ground. It would not, of course, be possible, by any exercise of dexterity, to fill an open vessel exactly full of liquid, and no more; nor, supposing that condition reached, could it be verified by simple observation. Should any air bubbles be inclosed within the covering, they are brought by management to the centre of the plate, where there is a small perforation, through which the deficiency of fluid may be supplied. The filling having been perfectly accomplished, the exterior of the vessel and cover are then carefully dried before weighing.

weight of a cubic inch, or of some other determinate volume, of water, there has been devoted a vast amount of laborious experimental inquiry; with results which differ only by a few one-thousandths of a grain per cubic inch, and which are at length probably as near to accuracy as it is possible for human skill to attain.

In the prosecution of this inquiry the method pursued has not been to prepare first a vessel of measured capacity, and then to ascertain by the balance what weight of water in ounces or grains it will hold. The difficulties already mentioned in the way of constructing capacity measures by actual direct measurement, prevent this. But the plan has been to prepare a solid of regular geometrical figure, and of specific gravity superior to water; and then to find experimentally the apparent loss of weight which this body undergoes, when immersed in water. The dimensions of such a solid can be determined with great accuracy. It displaces precisely its own bulk of the fluid; and the observed loss of weight is therefore directly the thing sought —that is, the weight of the same bulk of water.

The weight of the cubic inch of water at maximum density, as accepted at the Bureau of Weights and Measures of the United States, is stated by Mr. HASSLER, in a report to the Secretary of the Treasury, dated March, 1842, to be 252.7453 grains; and this is there said to have been deduced from the "English determinations;" and to be the value according to which the measures of capacity of the United States are adjusted. It is a little curious to observe, however, that the same authority gave, in his report of 1832—the report in which the regulating weights of those measures of capacity were first declared and prescribed —a materially different value of the same constant. In that report he states the capacity of the gallon to be two hundred and thirty-one cubic inches; and the weight of two hundred and thirty-one cubic inches of water at maximum density to be 58,372.1754 grains; from which it appears that the cubic inch of

water at maximum density was supposed by him then to weig[illegible]l only 252.6934 grains, as given in the text of the foregoing addres[illegible]s. This, however, is not a British determination; but it is M[illegible]r. HASSLER's own, deduced from the weight of an authentic kil[illegible]- gramme, described by him to be "an original kilogramme [illegible]f brass, standarded by the Committee of Weights and Measure[illegible]s in Paris [the committee on the 'definitive metre'] exactly equ[illegible]l with all those of the deputies of foreign nations present at th[illegible]e committee;" combined also with "an authentic metre of th[illegible]e committee," which he had himself twice compared. This valu[illegible]e of the kilogramme is 15,433.1669 grains, exceeding that found b[illegible]y Prof. MILLER, in 1844 (the value given implicitly on page 15), b[illegible]y 0.81816 grains. Mr. HASSLER's determination of the metre wa[illegible]s 39.3810327 inches, exceeding that received at the British Stand[illegible]- ard's Office, as established by KATER in 1818, by the small frac[illegible]- tion of an inch represented by the decimal 0.0102427. If w[illegible]e employ the numbers of MILLER and KATER, we shall find th[illegible] weight of the cubic inch of water *in vacuo*, at maximum density as deduced from the kilogramme, to be 252.87718 grains. Sup[illegible] posing the weighing to take place in air, it will be necessary t[illegible] deduct from this, the weight of the air which the water displaces, diminished by the weight of the air displaced by the counterpoises. In the British computations, the specific gravity of the counter- poise weights is taken at 8.5. The allowance for buoyancy must, according to this, be taken at $\frac{7.5}{8.5}$ ths of the weight of a cubic inch of air; or of a cubic inch of the water weighed, multiplied by the specific gravity of the air at the time of the experiment, taken with reference to water of that density. According to Mr. HASSLER, the value of this specific gravity which was employed by the French committee was $\frac{1}{770}$; and if we compute the correction upon this specific gravity, we shall find it to amount to 0.28978; so that the resulting weight of the cubic inch of water at maxi- mum density, weighed in air at 39°.83 F. and at 30 inches of barometric pressure, will be 252.5874.

This specific gravity is, however, too large, as is shown more at length in NOTE 2, following. It should be put at 0.001269582 $= \frac{1}{787.66}$; and if this value be employed, the correction will become 0.28978; and the weight of the cubic inch of water in the air at normal pressure, deduced from MILLER'S weight of the kilogramme, will be 252.58740 grains.

HASSLER'S weight of the cubic inch, as derived from his own authentic kilogramme, must be regarded as a weight *in vacuo;* although he treats it as a weight in air, and makes it the basis of his methods of adjusting the standards of capacity of the United States; in which adjustments the weighings take place, of course, in the air. He has not informed us whether, when his brass kilogramme was compared with the platinum standard, allowance was made for displacement; but we should naturally suppose that that was done, and the agreement of the weight with the weight of the prototype of the Archives, as found by Prof. MILLER, within about eight-tenths of a grain, is in favor of the supposition. Moreover, the effect of displacement in this comparison could only be slight. According to the determinations given in NOTE 2, following, the weight of air displaced by the brass kilogramme at the temperature of 62° F., and under 30 inches of pressure, would be only 2.20693 grains, and that of the platinum kilogramme 0.89328 grains. The resultant effect would therefore be 1.31365 grains; an amount by which Mr. HASSLER'S kilogramme ought to be increased in order to give the weight *in vacuo,* if the allowance was not originally made.*

But that the allowance *was* made can hardly be doubted; since Mr. HASSLER says, not that his brass kilogramme was *compared* merely with the platinum prototype, but that it was "standarded" by it—and that this was done, moreover, by the original standards-committee of 1799. The weight of the cubic inch of

* In determining the weight *in grains* of the brass kilogramme, after the comparison with the prototype, no allowance for displacement was necessary, the counterpoise weights being of the same metal.

water found from it, by dividing by the number of cubic inches in the cubic decimetre, as derived from his own authentic metre, which weight is 252.6934, is therefore a weight supposed to be taken *in vacuo* at the maximum density. This weight will be sensibly increased, if the cubic decimetre as determined by KATER (now generally received) be made the divisor; becoming in this case 252.89059 grains.

That Mr. HASSLER should have taken this weight, which is thus seen to be a weight *in vacuo*, as the basis of the adjustments of the national standards of capacity by weighings in the air, is a circumstance too remarkable to be credited, except upon the most conclusive evidence. His report of 1832 leaves, however, no doubt upon that point. In that report, after having stated that water at its maximum density "is very properly chosen to determine the bushel and gallon by the weight of distilled water which their legal capacity will contain," he proceeds to add: "Thus were determined, in weight of the Mint in Philadelphia, to contain distilled water at the maximum density, and at thirty inches barometer, the bushel =543,391.89 grains = 77.627413 pounds avoirdupois; the gallon =58,372.-1754 grains = 8.33888220 pounds."

If we now divide 58,372.1754 by 231, the "legal capacity" of the gallon in cubic inches, the quotient is exactly 252.6934, without remainder. If we divide 543,391.89 by 2150.42, the capacity of the bushel, the harmony of the two statements is not at first apparent; the dividend wanting a little more than five grains in order to furnish the same quotient; but we presently perceive that Mr. HASSLER has given to the bushel only 2150.4 cubic inches, dropping the last decimal; and that $252.6934 \times 2150.4 = 543{,}391.88736$; or, taking the nearest decimal in the hundredths place, 543,391.89, as stated in the report.

The value given, as mentioned above, by Mr. HASSLER, in his report of 1842, as being "the English determination," and

which is there stated by him to be the basis on which the United States measures of capacity are founded, is also given explicitly in the report of ten years before—*i. e.*, the same report in which, as we have seen, the standards of capacity are regulated in accordance with the weight derived from the kilogramme; so that the choice at that time seems to have been deliberately made. The difference between the values is not of serious importance, amounting only to eleven or twelve grains in a gallon; but it is certainly a logical error to found a measure of capacity which is to be adjusted by weighing in the air, upon a unit of weight which is true only *in vacuo*. It was perhaps also an error of judgment to derive this unit of weight from the kilogramme at all; when the remaining determinations cited in the report in which this choice is made, are discordant with this, and are generally harmonious among themselves.

It might be supposed that when Mr. HASSLER, in 1842, announced that the capacity measures of the United States were adjusted by weight in accordance with the English determination of the weight of the standard cubic inch of water, viz., 252.7453, he had modified the total weight of the gallon correspondingly; and this, if he had been silent as to that point, would necessarily have been taken for granted. He removes, however, the possibility of such an impression, by immediately stating, in the same report of 1842, that the weight corresponding to the gallon is 58,373 grains; a weight identical with the original determination, excepting that the decimal is dropped, and the last figure of the integral number is increased by a unit. If the British value had been actually employed, the gallon, in order to preserve its "legal capacity," should have been made to contain 58,384.1643 grains; or 11.9889 grains more than assigned it in 1832.*

* On supposition that the value 252.7453 grains is true, the actual standard brass gallon measure of the United States has the legal capacity of 231 cubic inches, not at the temperature of the maximum density of water, but 6°.52 F. above that temperature; or, putting the temperature of maximum density at 39°.1 F., the brass standard gallon contains 231 cubic inches at 45°.61 F.

The report of 1832 gives not only the determination called the English; but also the manner in which this value was deduced. It is a mean of several, all of which were obtained by reducing the weight given in the British act of Parliament of 1824 fixing the standards of capacity, as being that of a cubic inch of water taken at 62° F. of temperature and under a barometric pressure of thirty inches, to the temperature of the maximum density of water; by means of coefficients, experimentally determined, for the variation of density with changes of temperature. The value given in the act is 252.458 grains. It was derived originally from the very elaborate researches upon weights and measures of Sir GEORGE SHUCKBURGH EVELYN, a member of the Royal Society; of which a full account was published, in 1798, in the *Philosophical Transactions*. In determining, in the course of these researches, the weight of a given volume of water, Sir GEORGE made use of three different solids; one of them being a cube, one a cylinder, and one a sphere. In the year 1818, a Royal Commission was appointed and charged with the duty of inquiring and reporting on the subject of weights and measures, with a view to legislation. The chairman of this committee was Sir JOSEPH BANKS; and it embraced, among other distinguished members, Dr. WOLLASTON, Dr. YOUNG, and Captain HENRY KATER. The experimental inquiries instituted by the committee were chiefly conducted by Capt. KATER; and, in the course of them, this gentleman carefully revised the researches of Sir GEORGE SHUCKBURGH, remeasuring with microscopic accuracy the three solids which had been used by him. The weighings were not repeated. They had been made by means of a set of weights constructed expressly for the purpose by TROUGHTON; which weights accorded perfectly among themselves, but were a trifle light when compared with the parliamentary standard; the difference amounting to nearly two thirds of a grain in one thousand grains. The weighings were made in the air at different temperatures and under different pressures, the temperature of the water dif-

fering also from that of the air; but the results were all reduced to the standard temperature of 62° F., and the standard pressure of thirty inches of the barometer. The volume of the cube was 124.1969 cubic inches, at 62° F. of temperature; that of the cylinder, 75.2398 cubic inches; and that of the sphere 113.5264 cubic inches. The first gave the weight of the cubic inch of water, *in vacuo*, 252.907 of Sir GEORGE SHUCKBURGH's grains; the second 252.851, and the third, 252.907. The mean of these values is 252.888; which reduced to grains of the parliamentary standard is 252.722.

In making these reductions, every circumstance which could affect the result was carefully considered; the difference of bulk of the solid at the temperature of the experiment and at 62° F., as well as the difference of density of water at the same two temperatures, being computed with severe accuracy. The buoyant power of the atmosphere in diminishing the weight, not only of the solid immersed, but also of the counterpoise weights, was likewise taken into the account.*

The weight in the air deduced from the weight *in vacuo* given above, is obtained by subtracting the calculated weight of the air displaced by the water, less that of the air displaced by the counterpoises. The remainder, being multiplied by a coëfficient expressive of relative density at the two temperatures compared, gives the weight at the temperature of maximum density, and under the standard pressure.† Mr. HASSLER's report of 1832 gives three such coëfficients, derived directly or indirectly from GILPIN, with the weights obtained by means of them; and also the mean of these weights, which is 252.7487: but the particular result which is called, in the subsequent report, "the English determination," viz., 252.7453, is one given by VAN DER TOORN, of Amsterdam, from his own computations, based on GILPIN.

* From an examination of KATER's computations, it appears that the constants employed by him may, in some instances, be advantageously modified. His reductions have been, therefore, carefully re-examined, and the results are given in a separate note, which follows the present.

† This was Mr. HASSLER's order of proceeding: rigorous accuracy would require, however, that the reduction to maximum density should be made before correcting for buoyancy.

In the same report are also given four results from French authorities, with a mean of 252.7098 ; and quite a variety from VAN DER TOORN, ranging from 252.5658 to the one given above, viz., 252.7453. The results from British authorities, of which the mean is given in the last paragraph, are all higher than any from other sources. Of fifteen different determinations embraced in the table of the report, all except five are greater than that upon which Mr. HASSLER founded the capacity measures of the United States.

It is difficult to account for the not inconsiderable difference which appears, from the foregoing figures, to exist between the weight of the actual prototype platinum kilogramme of France, and the weight of the theoretic kilogramme, as deduced from the British experiments. The original determination of this standard was made with great care, in 1795, by M. LEFÈVRE GINEAU ; the method employed by him having been the same which has been described as used by Sir GEORGE SHUCKBURGH. The solid employed in the weighings was constructed in the form of a cylinder, such a body being capable of being constructed and measured with the greatest precision. It was hollow, being made only heavy enough to sink freely in water. In dimensions it was nearly two decimetres and a half in diameter, and of equal height. The exact mean height and diameter were determined by an extreme refinement of measurement to the ten thousandth of a millimetre, at the temperature of 17°.6 C = 63°.68 F. The volume computed upon these measurements was then reduced to the temperature of melting ice, at which it was determined to be very nearly 11.28 cubic decimetres = 688.385 cubic inches.

The weighings were made by means of weights prepared expressly for the purpose ; the unit being an approximate kilogramme, and the smaller weights, decimal sub-multiples of this down to the one-millionth part, carefully verified, and presumed to be less than one half of one one-millionth part in error. The counterpoise weights having been of the same metal with the

cylinder, no allowance for displacement was necessary in weighing in the air, the interior of the cylinder being in communication with the atmosphere during this operation. In weighing the cylinder immersed, the weight of the confined air was deducted as well as that of the air displaced by the weights. Thus, no precaution was neglected which seemed to be necessary to secure accuracy; and yet the resulting weight of the cubic decimetre of water as thus determined is sensibly less than that deduced by the British and by most of the continental experimenters.

Mr. CHISHOLM gives, however, in the Sixth Appendix to the Second Report of the British Standards commission, "an important computation of the actual weight of a cubic decimetre of water at its maximum density, in terms of the standard *Kilogramme des Archives*, the computation being based upon KUPFFER's observations of the weight of a cubic inch of water and of the standard kilogramme." The details of these observations and calculations are given in a voluminous report of the commission appointed to fix the standards of weight and measure of the Russian empire, published in 1841.

KUPFFER appears to have found the weight of the cubic inch of water *in vacuo*, at 13°¼ R. = 16°.67 C = 62° F., to be only 252.598 grains. He also found the weight of the standard kilogramme to be 15432.36186 grains; exceeding that found by Prof. MILLER by the minute fraction 0.01312. Mr. CHISHOLM remarks that, "according to this computation, based upon KATER's valuation of the metre, a cubic decimetre of water at its maximum density weighs 1000.0115 grammes; and therefore 11.5 milligrammes, or 0.17747 grains more than a kilogramme. By a similar computation, if Capt. CLARKE's more recent valuation of the metre = 39.370432 English inches be taken as the base, a cubic decimetre of water, at its maximum density, weighs 15 milligrammes, or 0.23145 grains *less* than a kilogramme. If the mean of these two computations be taken, the weight of a cubic

decimetre of water at its maximum density will be only 1.____ 75 milligrammes, or 0.027 grains less than a kilogramme."

Mr. CHISHOLM has carefully verified all the computations of KUPFFER, and remarks that "KUPFFER's operations for determ____ n-ing the weight of a cubic inch of water appear to have be____ en made with the greatest possible care and accuracy." He c____ n-cludes, however, with the observation, that "in point of fact, ____ he authority of a computation based upon the imperial weig____ ts and measures used by KUPFFER cannot be put in compari____ on with that based on the imperial *standards* used by SHUCKBUR____ GH and KATER;" and that "it may therefore be stated that the le____ al weight in a vacuum of a cubic inch of water at 62° Fahrenhe____ it, thus scientifically and authoritatively determined, is 252.7____ 22 grains."

One further remark remains to be added, in order that t____ e purpose of this note may be complete; which is in referen____ e to the mode of adjustment of the standard measures of cap____ city actually employed in practice at the Bureau of Weights an____ Measures. Though the weight of water which these standards should contain is that of a definite number of cubic inches taken at the temperature of maximum density, and under the barometric pressure of thirty inches, yet the adjustments are made at the ordinary temperature, and in any state of the barometer; the test weight which the vessels are made to contain being that which the expansion of the material from the standard temperature to the temperature of observation would adapt them to hold of the fluid, which also expands simultaneously. If it were true that the capacity of the vessel and the bulk of the contained liquid expanded equally throughout the range to which observation extends, then it would happen that the vessel would hold exactly the same weight of liquid under all variations of temperature. But this is not the case. Near the standard temperature, the capacity is enlarged by elevation of temperature more rapidly than the bulk of the liquid; and, therefore,

for a range of about twelve or thirteen degrees above the temperature of maximum density, the vessel is capable of holding a somewhat larger weight than at that temperature. But above the forty-sixth degree of Fahrenheit's thermometer, the volume of the liquid begins to expand faster than the capacity of the vessel; so that, at about 52° F., the weight of the water which the vessel will contain is once more equal to what it was at the standard temperature. This makes the temperature of 52° F. a particularly favorable one for the practical operations of the adjustment; and it is one which is more easy to command than that of 39° F.

The barometric corrections, according to Mr. HASSLER, are made on the supposition of a constant specific gravity of $\frac{1}{815}$, of air, under the normal pressure. In NOTE 2, which follows this, are stated some reasons for believing that this specific gravity is too small. By the method there described, the weight of a cubic inch of air of ordinary humidity under the pressure of 30 inches, at 52° F., is found to be 0.31124313; and this, divided by the weight of a cubic inch of water *in vacuo* at 62° F., as there found, viz., 252.75965, gives the specific gravity 0.001231400 $= \frac{1}{812.083}$. As in practice, however, the specific gravity appears to be made a factor in a coëfficient of correction, which is multiplied directly into the observed weight of the water in the vessel, the divisor should be the weight *in vacuo* of the cubic inch of water at 52° F. rather than at 62° F.; which weight is 252.94021 grains, giving a specific gravity of 0.001230501 $= \frac{1}{812.677}$. But as it is, probably, the water only which is taken at 52° F.; the weighing being made in air of ordinary temperature, or between 60° F. and 70° F., Mr. HASSLER's specific gravity will, under the actual circumstances, be very near the truth. It is however to be observed that, if the normal weight of the cubic inch of water at maximum density in air, be taken on supposition that the air is itself also at the temperature of 39.°1 F., there should be a correction for the thermic

condition of the atmosphere, as well as for pressure : and as this would, in general, be materially the greater of the two, it is apparently a needless refinement of accuracy to consider the fluctuations of the barometer, if the atmospheric temperature be disregarded. A cubic inch of air, under normal pressure, weighs, at 62° F., about one twenty-third part less than at 39° F. ; while even so large a barometric variation as an entire inch, affects, at constant temperature, the same weight, only one thirtieth part. Neglect of the first of these corrections would occasion error in the weight of the gallon to the extent of nearly three grains (2.88 gr.) ; while, in the case of the second, the error would ordinarily be less than one grain ; and would amount to only about two, on the supposition, just made, of the extreme barometric variation of an entire inch.

Supposing, however, that the regulating weight of the measures of capacity is *not* the weight in the air, but the weight *in vacuo*, of a cubic inch of water of maximum density, it is the *total* weight of the air displaced by the water, less that of the air displaced by the counterpoises, which should be allowed for in the adjustments. Such a regulating weight appears, as shown in the preceding note, to have been selected by Mr. HASSLER ; yet his formulas for correction are constructed as if this weight had been determined by weighing in the air under the normal pressure at the temperature of 62° F. Hence would follow the theoretic consequence, that the bushel and gallon, at the standard temperature, must be slightly above their legal capacity. But inasmuch as this regulating weight, derived as we have seen from the kilogramme, is below that deduced from the British experiments as being the weight under normal pressure in the air, there seems to be a probability that the error of the standard measures of capacity of the United States, if any exists, is on the side of deficiency rather than of excess.

NOTE 2.—REËXAMINATION OF CAPTAIN KATER'S DETERMINATION OF THE WEIGHT OF A GIVEN VOLUME OF WATER.

In recomputing Captain KATER'S results, referred to in the preceding note, employing his own data, some slight, though not very important, discrepancies are observed. The details of the recomputation are here presented.

I. FOR THE CUBE:

Temperature of air during the weighing. = 62° F.
" " water " " = 60°2 F.
Height of barometric column during the weighing..... = 29 inches.
Specific gravity of air at 62° F. and 30 inches barometer..... = $\frac{1}{834}$
Specific gravity of weights employed.... = 8.5.
Density of solid to density at 62° F. as unity..... = 1.0000567.
Density of water to density at 62° F. as unity..... = 1.00017.
Volume of solid at 62° F..... = 124.1969 cu. in.
Apparent weight of water displaced.... = 31,381.79 grains.

With these data, the following are the results obtained as compared with those originally deduced by KATER himself from the same.

1. Correction for displacement:

KATER'S RESULT.	RECOMPUTATION.
$31{,}381.79 \cdot \frac{1}{834} \cdot \frac{29}{30} \cdot \frac{7.5}{8.5} = 32.000.$	32.094.

2. Weight *in vacuo* of water displaced:

KATER'S RESULT.	RECOMPUTATION.
31,381.79+32.00 = 31,413.79.	31,381.79+32.094 = 31,413.884.

3. Reduction to the standard temperature:

KATER'S RESULT.	RECOMPUTATION.
$31{,}413.79 \cdot \frac{1.0000567}{1.00017} = 31410.24.$	$31{,}413.884 \cdot \frac{1.0000567}{1.00017} = 31{,}410.32$[illegible]

4. Weight *in vacuo* of cubic inch of water at 62° F.:

KATER'S RESULT.	RECOMPUTATION.
$\frac{31{,}410.24}{124.1969} = 252.907.$	$\frac{31{,}410.3264}{124.1969} = 252.90754.$

II. FOR THE CYLINDER:

In this case, the temperature of the air at the weighi[illegible]ng, and therefore, also, its specific gravity, remain the same as before. The stand of the barometer is likewise the same, a[illegible]nd the same counterpoise weights continue to be used. The ot[illegible]er conditions are different, as follows:

Temperature of the water during the weighing ..... = 60°5 F.
Density of solid to density at 62° F. .... = 1.000047.
Density of water to density at 62° F.... = 1.0001456.
Volume of solid at 62° F. ..... = 75,2398 cu. in.
Apparent weight of water displaced..... = 19,006.83 grain[illegible].

From which we obtain,

1. Correction for displacement:

KATER'S RESULT.	RECOMPUTATION.
$19{,}006.83 \cdot \frac{1}{834} \cdot \frac{29}{30} \cdot \frac{7.5}{8.5} = 19.43.$	19.4385.

2. Weight *in vacuo*, of water displaced:

KATER'S RESULT.	RECOMPUTATION.
19,00683+19.43 = 19,026,26.	19,006.83+19.4385 = 19,026.2685.

3. Reduction to standard temperature:

KATER'S RESULT.	RECOMPUTATION,
$19{,}026.26 \cdot \frac{1.000047}{1.000145} = 19{,}024.46.$	$19{,}026.2685 \cdot \frac{1.000047}{1.0001456} = 19{,}024.4123.$

4. Weight *in vacuo* of cubic inch of water:

KATER'S RESULT.	RECOMPUTATION.
$\frac{19,024.46}{75.2398} = 252.851.$	$\frac{19,024.4123}{75.2398} = 252.85035.$

III. FOR THE SPHERE:

The conditions in this experiment are all changed, excepting the specific gravity of the counterpoise weights. The rest are as follows:

Temperature of the air during the weighing ..... = 67° F.
Temperature of the water during the weighing ..... = 66° F.
Height of barometric column ..... = 29.74 inches.
Specific gravity of air at 67° F..... = $\frac{1}{843}$.
Density of solid to density at 62° F..... = 0.999874.
Density of water to density at 62° F.... = 0.99958.
Volume of solid at 62° F. ..... = 113.5264 cu. in.
Apparent weight of water displaced .... = 28,673.51 grains.
Whence we deduce—

1. Correction for displacement:

KATER'S RESULT.	RECOMPUTATION.
$28,673.51 \cdot \frac{1}{843} \cdot \frac{29.74}{30} \cdot \frac{7.5}{8.5} = 29.72.$	29.7519.

2. Weight *in vacuo* of water displaced:

KATER'S RESULT.	RECOMPUTATION.
28,673.51+29 72 = 28,703.23.	28,673.51 + 29.7519=28,703.2619.

3. Reduction to standard temperature:

KATER'S RESULT.	RECOMPUTATION.
$28,703.23 \cdot \frac{0.999874}{0.99958} = 28,711.66.$	$28,703.2619 \cdot \frac{0.999874}{0.99958} = 28,711.6992.$

4. Weight *in vacuo* of cubic inch of water:

KATER'S RESULT.	RECOMPUTATION.
$\frac{28,711.66}{113.5264} = 252.907.$	$\frac{28,711.6992}{113.5264} = 252.90768.$

	KATER'S RESULT.	RECOMPUTATION.
Resulting mean..... ...	252.888	252.8885
Mean in parliamentary grains.....	252.722	252.7225
Whence weight in air, 62° F. and 30 in. bar.	252.456	252.4551

In the final result the discrepancies which appear in the process of calculation nearly balance each other.

The computations of Captain KATER, here reviewed, form an appendix to the third report of the parliamentary committee of 1818. In the report itself, the weight of the cubic inch of water *in vacuo* at 62° F. is given as 252.754, and the Appendix is referred to as authority. The discrepancy between the two statements is not explained, but the statement of the report furnishes a reason if not a justification for the adoption in the British statute of 1824 (5 GEORGE IV., c. 74), of the value 252.458 as that of the weight of a cubic inch of water in the air, both water and air being at the temperature of 62° F., and the barometer standing at thirty inches—a value upon which Mr. HASSLER has based his reductions to the temperature of maximum density in his report of 1832; though, as is shown in the NOTE foregoing, he set aside the value found by these reductions in favor of that derived from his authentic brass kilogramme, in fixing the weights which determine the standard measures of capacity of the United States. Mr. HASSLER's reductions, here referred to, take no account of the different specific gravities of the air at the two temperatures considered; a circumstance which to a certain slight extent vitiates the result, whether the reduced weight be referred to air at 39°1 F., or to air at 62° F.

The specific gravities of air employed by Captain KATER in the calculation above reviewed are certainly too small. It is worth while, therefore, to repeat the operations with new constants. The following values for the weight in grains of a cubic inch of dry air at 60° F. of temperature, and under a barome-

tric pressure of thirty inches, are given by the several authorities named:

Biot and Arago	0.31074
Dumas and Boussingault	0.31086
Regnault	0.30938
Prout	0.31017
Mean	0.3102675

If we reduce to 62°, supposing the pressure constant, and assuming the absolute zero to be at 461° below 0° F., we shall obtain the result 0.30908093 grs.; and taking the cubic inch of water *in vacuo* at the same temperature to be 252.722 as above, we shall obtain a specific gravity of 0.0012230076, or $\frac{1}{817.656}$.

We may presume the weighings of the experimenters whose determinations are here cited, to have been made without allowance for the displacement of air by the counterpoise weights. The displacement of the air-vessel employed in the experiments would be the same, of course, before and after exhaustion.* The allowance for the counterpoises, if made, will slightly reduce the observed weight; and will reduce, of course, the resulting specific gravity. This allowance is made here accordingly, that nothing may be omitted which tends to diminish the difference between the specific gravities deduced from these weights and those employed by KATER. The counterpoises are supposed to be of brass, having the specific gravity of those used in the British experiments, viz., 8.5. The weight, after the correction thus indicated, becomes 0.309036458 grs.; and the resulting specific gravity is $0.0012228315 = \frac{1}{817.774}$.

This is on supposition that the air is dry. In RANKINE'S *Manual of the Steam Engine*, there are given tables of the pressure and weight per cubic foot of watery vapor from 32° F.

* In order to eliminate entirely the effect of displacement, in experiments on the weight of air and gases, the expedient was employed by REGNAULT and PROUT, of suspending to the opposite scale of the balance, a second vessel exactly similar in form and equal in weight to that containing the gas to be weighed.

upward. It is reasonable to assume the average depression of the dew point to be not less than six degrees. If, therefore, to the weight of a cubic inch of dry air as already found, we add the weight of a cubic inch of watery vapor, supposed saturated at a temperature six degrees below, and if from the same we subtract a fraction of its total weight indicated by the ratio of the tension of the vapor to the total tension, the result should be the ordinary weight of a cubic inch of air at the standard temperature and pressure. These operations having been performed, we find at length the weight at 62° F., proper for our purposes, to be 0.307386258 grains; giving a specific gravity of $0.001216302 = \frac{1}{822.164.}$ A similar computation gives the weight of a cubic inch of air at 67° F. and 30 inches of pressure as 0.304150644 grs., with a specific gravity to water at 62° F., of $0.001203498 = \frac{1}{830.91.}$

In the calculations given below, these values are employed; and the densities of water at different temperatures, instead of being taken from GILPIN, are derived from the more recent determinations of KOPP. The constants for the expansion and contraction of brass remain as stated by KATER. The temperature of the maximum density of water as given by HASSLER (39°.83 F. = 4°.35 C.) is doubtless too high. It is given by CHISHOLM, on the authority of PLAYFAIR and JOULE, (*Second Report of the Royal Standards Commission*, 1869, Appendix VI.) at 3°.945 C. = 39°.101 F.; and inasmuch as the variation of density is almost insensible near that point, we may assume it for the purposes of this calculation at 4° C = 39°.2 F.

The following then are the coëfficients of volume of water at the several temperatures named, as taken directly or deduced by interpolation from the tables of KOPP.

At 32° F.=	0°.0 C 1.000000	At 60°.5 F.=	15°.83 C. 1.000820
" 39.2 " =	4.0 " 0.999877	" 62.0 " =	16.67 " 1.000953
" 60.2 " =	15.662" 1.000795	" 66.0 " =	18.89 " 1.001350

For the dilatation and contraction of brass, if we take the density at 62° F. as unity, we shall have the following coefficients.

For 60°.2 F.....	1.00005670	For 62° F.	1.00000000
" 60.5 "	1.00004725	" 66 "	0.99987400

Putting now

W = the apparent weight of the water displaced.

W' = the weight after correction for displacement.

W'' = the corrected and reduced weight, being the weight at 62° F. *in vacuo*.

S = specific gravity of dry air at 62° F. to water at 62° F.

C = correction of S for humidity. It is the weight per cubic inch of saturated aqueous vapor at 6° F. below the temperature of observation, less the proportion of the total weight per cubic inch of vapor and dry air, expressed by the ratio of tension of vapor to joint tension of vapor and air,—divided by the weight per cubic inch of water at 62° F. *in vacuo*.

s = specific gravity at 62° F. of body weighed to water at 62° F.

T = British standard temperature (62° F.), referred to the absolute zero (−461° F).

t = temperature of the air at the weighing, referred to same.

P = standard barometric pressure.

p = barometric pressure at the weighing.

V = coefficient of volume of water at 62° F., from table.

v = " " " " at temperature of experiment.

D = density of brass at 62° F.

d = " " at temperature of experiment.

C = correction for displacement.

The correction for displacement, to be added to W, will be found by the formula,

$$C = W \cdot \left(S \cdot \frac{T}{t} + c \right) \cdot \frac{v}{V} \cdot \frac{p}{P} \cdot \frac{s\,D\,v - D\,V}{s\,D\,v}.*$$

This correction having been added to W, the sum W′ will represent the weight *in vacuo* of the volume of water actually displaced by the solid, with the density belonging to the water at the temperature of the experiment. This volume is then to be reduced to the volume at 62° F., by means of the coefficients of density of brass given above; and the density, to the density at 62°, by means of those of volume for water, in accordance with the following formula,

$$W'' = W' \cdot \frac{v}{V} \cdot \frac{D}{D'}.$$

Performing the operations and putting C_A, C_B, C_C, W_A, W_B, W_C to represent the several corrections, and the several weights as corrected, we find,

$$C_A = 32.5513. \quad C_B = 19.7157. \quad C_C = 30.5180.$$

And

$$W_A = 31,414.3413. \quad W_B = 19,026.5457. \quad W_C = 28,714.0280.$$

These, further reduced by the second formula, give

$$W_1 = 31,411.0808. \quad W_2 = 19,024.8829. \quad W_3 = 28,711.7140.$$

Whence, dividing by the measured bulks of the solids immersed, there are obtained the three values for the weight of the cubic inch of water *in vacuo* at 62° F., and 30 inches of barometric pressure, 252.9136 grs., 252.8566 grs., and 252.9959 grs.; giving a mean of 252.9220 grs. This weight being expressed in the grains of Sir George Shuckburgh, must be reduced to the parliamentary standard, by multiplying by the coefficient 0.9993432 which gives as a final result, 252.75965 grs. standard.

There is reason, therefore, to think that the reductions made by Captain Kater from the experiments of Sir George Shuck-

* This last factor $\frac{s\,D\,v - D\,V}{s\,D\,v}$ is put into this form only because it is what the rigid theoretic truth requires. Practically the specific gravity, s, may be regarded as invariable; and in place of this factor, may be written $\frac{s-1}{s}$.

BURGH, after the remeasurement of the solid bodies employed in those experiments had been carefully made by himself, give a result sensibly though slightly too small, the difference amounting to 0.038 grs. nearly.

If, from the weight just found, we deduct the proper correction for displacement in weighing in the air, at the British standard temperature and pressure, with brass weights of the specific gravity of 8.5, we shall obtain for the cubic inch of water under these conditions, the value 252.48843 grs. instead of 252.456, the result found by KATER.

Reducing the weight *in vacuo* found above to the temperature of maximum density, by means of the coefficients of volume from the table of KOPP, we find for the cubic inch of water under these conditions, the weight 253.0286. KATER's value 252.722, reduced by means of the coefficient of Prof. MILLER employed in the report of 1869 of the Standards Commission of Great Britain, gives 253.00452 grs. The corresponding value, as deduced from the kilogramme, according to MILLER, we have seen to be only 252.87718 grs.* The difference is 0.12734 grs.; which, multiplied by 61.02705152, the number of cubic inches in a cubic decimetre, gives 7.77118 grs., the amount by which the platinum prototype kilogramme of the Archives would appear, from this determination, to be too light. If the comparison be made with the value found in the foregoing computation, viz. :

*As there are three determinations of the weight of the kilogram in British standard grains, all entitled to respect, viz.: (taken in the order of publication) those of HASSLER (1832), KUPFFER (1841), and MILLER (1844); and also three determinations of the meter in British standard inches, and therefore of the cubic decimeter, or *liter*, in British standard cubic inches, similarly deserving of consideration, viz.: (taken likewise in the order of publication) those of KATER (1818), HASSLER (1832), and CLARKE (1866), it follows that, by combining these data by pairs, we may obtain nine values, slightly differing from each other, for the weight *in vacuo* of the cubic inch of water at maximum density, as derived from the kilogram. It may be interesting to have all these under the eye in a single group. The data are as follows:—

	HASSLER.	KUPFFER.	MILLER.
Kilogram (grains) . . .	15,433.1669	15,432.36186	15,432.34874
	KATER.	HASSLER.	CLARKE.
Meter (inches)	39.37079	39.3810327	39.370432
Liter (cu. in.)	61.02705152	61.07469320	61.02538677

Taking, now, the initial letters of the names of these authorities to indicate the several

253.0286 grs., the discrepancy becomes as great as 9.24072 grains.*

Returning to the weight of the cubic inch of water *in vacuo* at maximum density, as found by our own reductions above, we shall obtain the weight in air at the corresponding temperature, by correcting, as in previous computations, for displacement. From the weight of the cubic inch of dry air at 62° F. and at the normal pressure, we deduce the weight at 39°.1 F. under the same pressure, by the ordinary methods; which weight we find to be 0.323187315 grs. Correcting then, as in the previous cases, for humidity, we obtain the reduced weight 0.321240544 grs. And multiplying this by the constant 0.882353, which expresses the displacement by the water (taken as unity) less the displacement by the brass weights, we arrive finally at the correction 0.2834476 grs., which is to be subtracted from the weight *in vacuo* as found above, viz., 253.0286 grs.; leaving finally

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value of the kilogram and of the liter, and using the large capitals for the first, and the small capitals for the second, we have these combinations:

Weight. Cu. in. water, *in vacuo*.	Weight. Cu. in. water, *in vacuo*.	Weight. Cu. in. water, *in vacuo*.
H ÷ K = 252.89059	K ÷ K = 252.87739	M ÷ K = 252.87718
H ÷ H = 252.69331 *(a)*	K ÷ H = 252.68013	M ÷ H = 252.67992
H ÷ C = 252.89748	K ÷ C = 252.88429	M ÷ C = 252.88407

(a) This falls short of the value given by Mr. Hassler himself (252.6934) by one ten thousandth of a grain The difference arises from the fact that, in his value of the liter, the fifth decimal figure is 6 instead of 9, as, from his value of the meter, it should be.

The largest of these values is obtained from Hassler's kilogram and Clarke's meter; the smallest from Miller's kilogram and Hassler's meter. The mean of the whole is 252.81826 grains; which is less than the result of the computation in the text by 0.21034 grs. The mean of the liters is 61.04237716 cubic inches; and if the difference just found be multiplied by this, the kilogram of the Archives will appear to be below the theoretic weight as determined by the British experiments, to the extent of 12.83965 grains. Rejecting the values dependent on the meter of Mr. Hassler, we shall have a mean of 252.88375 grains, for the cubic inch of water, and a mean liter of 61.02621914 cubic inches. This mean weight falls below the computation in the text by 0.14485 grs.; indicating that the prototype kilogram is 8.83965 grains light. But if the comparison be made with the weight deduced from the report of the Standards Commission, as given above, viz., 253.00452, the apparent deficiency per cubic inch is only 0.12077 grs., and the inferred deficiency of weight of the prototype kilogram is reduced to 7.37014 grains.

*In the Report above referred to, of the Standards Commission to the British Parliament, made in 1869, the Warden of the Standards, H. W. Chisholm, Esq., singularly enough inverts this statement, and says that the standard kilogram is "*in excess of its theoretical weight*." According to his computation, the difference is 7.76247 grains.

252.7452 grains as the weight of the cubic inch of water in air at 39°.1 F., and under thirty inches of barometric pressure. This value is identical with that of VAN DER TOORN, given by HASSLER, in his report of 1832, as "the English determination," excepting only the slight difference of a unit in the fourth decimal place. The coincidence is remarkable, in view of the widely different processes by which the two have been reached.

Dividing the weight of the cubic inch of humid air at 39°.1 F., as found above, by the weight of the cubic inch of water at maximum density, we shall have, as the specific gravity of air under these circumstances, $0.001269582 = \frac{1}{787.66}$. It is this specific gravity which ought to be employed in the corrections for barometric fluctuations during the adjustment of measures of capacity, in case the weight of the standard cubic inch of water according to which their capacities are computed, has been determined on supposition that the air as well as the water is at the temperature of maximum density of water; and that the adjustments are made in an atmosphere of the same temperature. On this supposition, the weight 252.7452 grains, just found, is the proper standard weight of the cubic inch of water; but if this standard weight is supposed to be taken with water at the maximum density and air at 62° F., its value ought to be stated at 252.7574 grains. The difference, as is pointed out in the preceding note, will affect the weight of the gallon to the extent of nearly three grains.

APPENDIX C.

NOTE ON BRITISH LEGISLATION IN REGARD TO THE METRIC SYSTEM.

(REFERRED TO ON PAGE 49.)

The history of British legislation in regard to the Metric System of Weights and Measures having been but imperfectly given in the text of the foregoing address, it has been thought proper to append the following succinct account of it, extracted from a paper by H. W. CHISHOLM, Esq., Warden of the Standards of Great Britain, which was published in connection with the "Second Report of the Standards Commission," in 1869.

Mr. CHISHOLM says:

"The last evidence which I shall bring before the Commission of the progress of public opinion in this country as to the introduction of the Metric System, is that of the proceedings in Parliament. And first, as to the Weights and Measures Committee of 1862. That Committee was composed of members who formed opinions entirely favorable to the introduction of the Metric System, and the terms in which their recommendations are framed in their report deserve particular notice.

"'They 'arrived at a unanimous conclusion that the best course is cautiously but steadily to introduce' 'the Metric System into this country,' and they recommended—

"'1. That the use of the Metric System be rendered legal. No compulsory measures should be resorted to until they are sanctioned by the general conviction of the public.

"'2. That a Department of Weights and Measures be established in connection with the Board of Trade. It would thus be-

come subordinate to the Government and responsible to Parliament. To it should be intrusted the conservation and verification of the standards, the superintendence of inspectors, and the general duties incident to such a department. It should also take such measures as may from time to time promote the use and extend the knowledge of the Metric System in the Departments of Government and among the people.

"3. The Government should sanction the use of the Metric System (together with our present one) in the levying of the customs duties, thus familiarizing it among our merchants and manufacturers, and giving facilities to foreign traders in their dealings with this country. Its use, combined with that of our own system in government contracts, has also been suggested.

"4. The Metric System should form one of the subjects of examination in the competitive examination of the Civil Service.

"5. The gramme should be used as a weight for foreign letters and books at the Post Office.

"6. The Committee of Council on Education should require the Metric System to be taught (as might easily be done by means of tables and diagrams) in all schools receiving grants of public money.

"7. In the public statistics of the country, quantities should be expressed in terms of the Metric System, in juxtaposition with those of our own, as suggested by the International Statistical Congress.

"8. In private bills before Parliament the use of the Metric System should be allowed.

"9. The only weights and measures in use should be the Metric and Imperial, until the Metric System has been generally adopted.

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"As a consequence of the report of the committee of 1862, a bill to introduce the Metric System was introduced in the following session, founded on their recommendations; but it also

contained the provision that it should be made compulsory at the expiration of a period to be fixed by the bill. A period of three years was inserted in the draft of the bill, although it was stated by its promoters that a longer period might be fixed, as might be judged expedient or necessary. The compulsory provision was objected to by the Government; but, on a division, the second reading was carried by 110 against 75 on July 1st, 1863. The lateness of the session prevented the bill being then proceeded with; but it was re-introduced in 1864 as a permissive bill only. The second reading on 10th March was not opposed by the Government, and was carried on a division by 90 against 38. In committee on 4th May, the Government objected to the provisions for legalizing Metric standards and weights and measures, there being no arrangements for providing them, and proposed themselves to substitute a new bill, rendering the Metric System permissive in this country so far as related to contracts. This proposal was acceded to, and the bill finally passed as the Metric Act of 1864, though not until after a division upon the second reading in the House of Lords on 21st July, of 34 against 23.

"In 1868, another bill was brought in, to repeal the act of 1864, and introduce the Metric System compulsorily, after a period to be fixed in the bill, which period was left to be inserted by the Government. Upon the second reading of the bill, on 13th May, 1868, it was not opposed by the Government, on the understanding that they did not object to its principle, but that further information was required before the question could be properly dealt with, and was then being obtained by the Standards Commission, and that the bill should not be proceeded with until the report of the commission had been received. This understanding was assented to by the promoters of the bill, and the bill was read a second time after a division of 217 against 65.

"The time has now arrived when all the evidence that appears to be required to form their judgment has been placed before

the Standards Commission, and when the whole question has become ripe for their opinion to be given upon it. Upon full consideration of all the circumstances, and after the adoption of the Metric System by so many other countries, and the influential and increasing support it has met with here, I am myself led to the irresistible conviction that the full introduction and legalization of the Metric System in the United Kingdom can no longer be delayed. Considering the extent and importance of our commercial and scientific intercourse with so many nations who have adopted the Metric System of weights and measures, and that it has now become really a widely extended international system, it appears to me that this country can no longer isolate herself from other countries in her system of weights and measures, and refuse to adopt that common method of computing the quantities of all merchandise and other articles passing between them, which so many other nations have already accepted."

The views here expressed by Mr. CHISHOLM were approved by the commission,* who, in the report above referred to, submitted the following among their recommendations to Parliament:

"(1.) Considering the information which has been laid before the Commission—

"Of the great increase during late years of international communication, especially in relation to trade and commerce;

"Of the general adoption of the Metric System of weights and measures in many countries, both in Europe and other parts of the world, and more recently in the North German Confederation and in the United States of America;

"Of the progress of public opinion in this country in favor of the Metric System as a uniform international system of weights and measures;

* The commission was composed as follows;—GEORGE BIDDELL AIRY (Astronomer Royal), Chairman; Lord COLCHESTER; Mr. STEPHEN CAVE; Mr. JOHN GEORGE SHAW LEFEVRE; General EDWARD SABINE; Sir THOMAS GRAHAM (Master of the Mint); Mr. W. H. MILLER (of the Bank of England), and Mr. H. W. CHISHOLM (Warden of the Standards).

"And of the increasing use of the Metric System in scientific researches, and in the practice of accurate chemistry and engineering construction;

"We are of opinion that the time has now arrived when the law should provide, and facilities be afforded by the Government, for the introduction and use of Metric weights and measures in the United Kingdom.

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"(2.) Considering the advantage of adopting in an international system not only of uniform weights and measures, but also uniform names; and that although there may be well founded objections to the inconvenient length and occasional similarity, both to the eye and ear, of the French nomenclature, yet it is probable that these names will become familiar by custom, and obtain popular abbreviations;

"We think that the French nomenclature, as well as decimal scale of the Metric System, should be introduced in this country.

"(3) Considering—

"That there is no immediate cause, requiring a general change in the existing system of legal weights and measures of the country for the purposes of *internal* trade;

"That the statutable values of the fundamental imperial units are adopted in use without the slightest variation throughout the whole of the British Isles;

"That the primary Imperial Standards are as perfect as can be made by modern skill and science, and that the whole series of official standards are now most accurately verified in relation to the primary standards. * * * * *

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"We are of opinion that the *general* introduction of the Metric System should be permissive only, and not made compulsory by law after any period to be now specified, so far as relates to the

use of Metric weights and measures for weighing and measuring goods for sale or conveyance. * * * * * *

"(5) We are of opinion that it is expedient that customs duties should be allowed to be levied by Metric weight and measure, as well as by Imperial weight and measure; that the use of the Metric System concurrently with the Imperial System, should be adopted by other public departments, especially the Post Office, and in the publication of the principal results of the Statistics of the Board of Trade, as well as for the admeasurement and registration of the tonnage of shipping;

"(6) And that mural standards of the Metric System, as well as of the Imperial System, be exhibited in public places.

"(7) Considering—

"That the Metric System, as adopted in other countries, includes the relation of coinage to weights and measures, particularly in its uniform decimal scale;

"And that the advantages of the introduction of the Metric System into this country, as an international system of weights and measures, would be much increased by establishing a corresponding international system of coinage, in regard to a unit and to a decimal scale;

"We are of opinion that, even if the difficulties of establishing an international unit of coinage cannot be at present overcome, yet the decimalization of our system of coinage, which is in the power of the Government, would be very useful to the public."

These very judicious recommendations of the Standards Commission are believed to have met with the general approval of the thinking people of Great Britain. As yet however the national legislature has not taken the decisive step which is evidently inevitable at no distant day, of adopting the Metric System of Weights and Measures as the only system to be legally used in the United Kingdom. During the recent session of Parliament (1871), a bill was introduced having this object in view, which, being opposed by the ministry, was lost on a very

close division. The following extracts from a report of the debate on the subject in the House of Commons, are derived from the London *Guardian*, of August 2, 1871:

"On Wednesday [July 26], Mr. J. B. SMITH moved the second reading of his bill for the compulsory introduction of the metric or decimal system. The honorable member, after dwelling on the curious jumble of weights and measures which were still in vogue amongst us, said that the act of 1864 was so badly drawn by the Board of Trade that in the opinion of the law officers the Metric System was legal, and yet that if metric weights and measures were found on a man's premises he was liable to prosecution. The Metric System was in compulsory use amongst 200,000,000 people, and in permissive use amongst 200,000,000 more. In fact, sixty-six per cent. of our exports went to countries using that system; and its introduction amongst us would save infinite trouble, first, in education, and afterwards in the operations of commerce. Moreover, Sir ROWLAND HILL had further stated that we were losing six per cent. on our postage with France, and seventeen per cent. on our postage with Prussia, in consequence of a want of identity in weights and measures.

"The bill was supported by forty-three Associated Chambers of Commerce and Agriculture, by Farmers' Clubs, Workingmen's Associations, and many scientific bodies. It was supported by the representatives of the largest constituencies in the kingdom —Manchester, Liverpool, Glasgow, Leeds, Birmingham, North Staffordshire, South Leicestershire, and South Norfolk. It was opposed by the member for Cambridge University, on the ground that the French unit was not a proper unit; by the Astronomer Royal and Sir J. HERSCHEL. For the Metric System however they had the authority of three gentlemen who possessed the most extensive scientific knowledge, combined with the greatest business knowledge of this or any other age—Sir WILLIAM ARMSTRONG, Sir JOSEPH WHITWORTH, and Sir WILLIAM FAIRBAIRN.

"In a word, he asked for what the English barons had demanded 700 years ago—namely, that there should be one weight and one measure throughout the land, but he asked that that weight and that measure should be identical with those of other nations, so that, like a common language, there should be but one weight and one measure throughout the world."

The passage of the bill was resisted on the usual grounds, and on some that are unusual. For instance—

"Mr. BERESFORD HOPE, in moving the rejection of the bill, said that, while he was in favor of uniformity, he desired to have English weights and measures, and not French ones. The changes proposed by Mr. SMITH would overthrow all our long-established habits and customs—nay our very proverbs; for no one would be able hereafter to talk about 'giving an inch and taking an ell'—(a laugh):—"

This latter argument of Mr. BERESFORD HOPE is rather more witty than weighty, but it is less true than either: for though the ell (which after all is a French measure) has ceased to be used in England for a century or two, the proverb seems to be still as lively as ever. As for stigmatizing the Metric System as *French*, it was never quite just to do so, and it is at present altogether absurd; since this system has become the system of more than half the civilized world.

"The rejection of the bill was seconded by Mr. STEVENSON, and was supported by Mr. SCOURFIELD, by Alderman LAWRENCE, who pointed out that the adoption of the *litre* would diminish the poor man's pint of beer without any proportionate diminution of price, [a surprisingly knowing alderman this must have been] and by Mr. FOTHERGILL. Mr. HENLEY pointed out the inconvenience of having to go to a foreign capital for standards which might at any moment be melted down in a general conflagration of the city. If agriculturists wanted a uniform measure, why on earth did they not adopt the Imperial bushel?"

The honorable gentleman proceeded, "When the Government

could say there was a reasonable certainty that all other nations would adopt the same uniform system, it would be time enough to ask our people to bear such a tax, and to make a change which would create great internal confusion. [Let us suppose "all other nations" to wait in like manner for "all others"—what would probably be the rate of progress?] They knew what had happened in France; how Frenchmen first began to cut off their king's head [it is commonly supposed they finished], declared there was no God, set up a social evil as an object of worship, and cast aside all the ancient provinces and limits of the land. There was also an enormous change of property, almost to the extent of being universal; and when that was done, they set about measuring the world, and enforced that unit which people were so fond of throughout France, where they had a vast number of different measures in every province. He would be glad to hear how long it took, with all the despotism they had in France, before the old system of weights and measures was fairly got rid of. That was a matter upon which the government ought to give them some information." [Here is a gentleman who evidently ought to read the reports of his own "Standards Commission."]

"The bill was supported by Sir C. ADDERLEY, by Mr. BAINES, by Mr. CLARE READ (who said he had bought and sold in Oxfordshire, Norfolk, and Pembrokeshire by different weights for different articles; and in Shropshire, where they actually had different weights for different market days), by Mr. PELL, by Col. SYKES, and by Mr. ILLINGWORTH. Mr. CHICHESTER FORTESCUE, the President of the Board of Trade, said that this was the first time the issue had been really raised in Parliament; for the purport of the measure of 1864 was much misunderstood. It was true that it bore the title of an act to legalize the use of metric weights and measures; but all it did was to render contracts under the metric system legal, which they were not before; but it by no means legalized the use of those weights and measures in this country. * * * In his opinion the general feeling of

this country was not at present such as would justify the compulsory introduction of the metric system. Under all the circumstances it would be better to postpone the consideration of the matter, and leave it to the government to introduce a complete system next session." [Here was a *quasi* promise on the part of the ministry to favor the introduction of the system at a later day, and possibly with less abruptness. Perhaps it would have been better to accept the overture, but the friends of the bill thought otherwise.]

"Mr. EASTWICK advised Mr. SMITH to accept this offer: but the honorable member insisted on a division, and was beaten by eighty-two to seventy-seven."

In connection with the foregoing account of the home legislation of Great Britain, the following statement, derived from a little volume recently published, (June, 1871), by Professor LEONE LEVI, of London, Honorary Secretary of the Metric Committee of the British Association for the Advancement of Science, will be found interesting as it respects the simultaneous movement of public opinion, and its effect upon metrological reform, in British India:

"The necessity," says Prof. LEVI, "of providing for uniformity of weights and measures in India, engaged the attention of the Indian Government frequently since 1837. On the 13th of May, 1863, the Government of Madras suggested the importance of steps being taken to reform the various systems of weights and measures, and on the 20th June, 1864, a resolution was passed by the Government of India, recommending the appointment of local committees in each Presidency, to deliberate and report on the whole matter. At Madras and Bombay, in the north-western provinces, and the Punjaub, the committees reported in favor of a scheme based upon the Imperial system. But the Bengal Government proposed the gradual but finally complete adoption of the Metric System, which recommendation received the support of the Bengal Government. On the 1st October, 1867, Colonel STRACHEY, President of the Central Committee, published

a memorandum in support of the proposal of the Bengal Committee, and included in it a draft of a bill on the subject. The majority of his colleagues were, however, opposed to his measure, and Colonel STRACHEY retired from the Committee, which afterwards reported against the adoption of the Metric System, and recommended the scheme based on the Imperial. At about this time a deputation of the Metric Committee of the British Association and the Council of the International Decimal Association, waited on Sir STAFFORD NORTHCOTE, urging the superior claims of the Metric System for India, which was communicated by him to the Indian Government. And on the 5th September, 1868, a decisive Minute was made by the Commander-in-Chief, Sir W. R. MANSFIELD, in favor of the Metric System with regard to weights. Sir JOHN LAURENCE approved of the Minute, and so did the Hon. Sir R. TEMPLE. The matter was then referred by the Governor-General in Council to the Duke of Argyle, Secretary for India, who consulted the Board of Trade on the subject. The approbation of the Board having been duly obtained, an act was passed in 1870 to regulate the weights and measures in British India. The act constituted the primary standard of weight, the *Ser*, of the same weight as the kilogramme, and the primary standard of length, the metre; and it empowered the Governor-General in Council to cause such new weights and measures to be used by any government office or municipal body or railway company; and to require that, after a date to be fixed, all or any of the weights and measures of capacity aforesaid shall in every district be the basis of the dealings and contracts of all persons engaged in any specified business or trade. It also provided that after the date fixed in any such notification, all dealings, or contracts made by the officers, bodies, companies, or persons so mentioned, for any work done or goods sold by weight or measure, shall, in the absence of a special agreement to the contrary, be deemed to be had or made, according to the weights and measures directed in such notification to be used.

APPENDIX D.

NOTE ON THE EXTENT TO WHICH THE METRIC SYSTEM HAS BEEN ALREADY ADOPTED.

(REFERRED TO ON PAGE 51.)

The statements of the foregoing address as to the populations among whom the metric system has been wholly or partially legalized, though made upon less full information than has since been collected, have been generally allowed to stand as they were originally written. The object of this note is to present a more complete view of the facts, (so far as ascertained up to December, 1871,) than could be introduced into the body of the address, without too largely changing its form. In the following tables are embraced, by classes, all the nations whose legislation is known to have favored this system; distinction being made between those which have adopted the system in full; those which have established simple relations of commensurability between it and their own; those which, still retaining their own unit bases, have adopted metric ratios for the derivative denominations; and, finally, those which have made the use of the system optional but not compulsory.

I.—*Peoples adopting the Metric System in full.*

STATE.	YEAR.	POPULATION.
France	1866	38,067,064
French Colonies	1866	2,921,000
Holland	1868	3,638,467
Dutch Colonies	1868	22,453,000
Belgium	1866	4,839,094
Spain	1868	16,642,000

TABLE I.—*Continued.*

STATE.	YEAR.	POPULAT
Spanish Colonies	1868	2,03
Portugal	1863	4,34
Italy	1868	25,52
North German Confederation	1867	29,91
Greece	1864	1,34
Roumania	1867	4,60
British India	1866	150,76
Mexico	1865	8,21
New Granada	....	2,80
Ecuador	1858	1,04
Peru	....	3,37
Brazil	1867	9,85
Uruguay	....	38
Argentine Confederation	1869	1,73
Chili	1868	1,90
Total	....	336,41

II.—*Peoples adopting Metric Values.*

STATE.	YEAR.	POPULAT
Würtemberg	1867	1,77
Bavaria	1867	4,82
Baden	1867	1,43
Hesse	1852	85
Switzerland	1860	2,51
Denmark	1850	2,41
Austria	1867	34,86
Turkey	....	35,36
Total	....	84,03

III.—*Countries in which the Metric System is permissive.*

STATE.	YEAR.	POPULAT
Great Britain	1871	31,81
United States	1870	38,55
Total	....	70,37

IV.—In Sweden (population (1867) 4,195,681) and Norway (1867) 1,701,478, total=5,897,159) the decimal division has been adopted without as yet the metric values.

As the peoples in the second class above may be regarded as committed to the ultimate adoption of the metric system in full, we may count, as already enlisted on this side of the question, a total of about 420,000,000.

CORRECTION.—The statement, on page one hundred and seventy, that the Third Report (made in 1821) of the British Standards Commission of 1818, gives, as the weight *in vacuo* of the cubic inch of water at 62° F., 252.724 grains, while the Appendix to the Report referred to as authority, gives 252.722, is erroneous as it respects the first of these numbers. The Report (*British Parliamentary Papers*, 1821, Vol. IV.), gives 252.72; differing from the Appendix only in the omission of the third decimal figure.

The error was made in consequence of depending on an extract from the Report (which purports to be literal) given by Dr. YOUNG in his article on Weights and Measures, in the *Encyclopedia Britannica*; in which the weight in question is stated at 252.724 grs., although the Appendix, which is quoted entire in the same article, gives as above 252.722 grs.

The bill, founded on this and the preceding reports, which was introduced into Parliament in 1822, but not passed, adopted the number of the Report above, viz., 252.72 grs. The bill introduced in the following year, which was finally, with some slight modification, passed June 17, 1824, but not carried into operation until January 1, 1826, assumed the weight in question to be 252.724 grs.—the same number which Dr. YOUNG has erroneously introduced into the extract from the Report quoted by him. The act fixed the capacity of the imperial gallon by requiring that this measure should contain seventy thousand grains of distilled water of the temperature of 62° F., weighed by brass weights under the barometric pressure of thirty inches, and stating at the same time the capacity thus determined to be 277.274 cubic inches. From these data we infer the weight of the single cubic inch of water in the air, under the prescribed conditions of temperature and pressure, to have been supposed to amount to 252.458 grains; since $252.458 \times 277.274 = 70{,}000.039492$, exceeding the prescribed weight of the gallon of water by less than four one-hundredths of a grain.

In the bill of 1822, the capacity of the gallon was fixed at 277.276 cubic inches; corresponding to the weight of the cubic inch of water in air (under the conditions specified) as given in the Appendix to the Report, viz., 252.456 grs. Thus $277.276 \times 252.456 = 69{,}999.989856$ grains; which is less than 70,000 by the insignificant fraction 0.010144. Before the final passage in 1824,

of the bill of 1823, the weight *in vacuo* was thrown out, and the weight in the air substituted; and it was then explicitly declared to have been "ascertained by the Commissioners appointed by his Majesty, &c., that a cubic inch of distilled water, weighed in air by brass weights, at the temperature of sixty-two degrees of FAHRENHEIT'S thermometer, the barometer being at thirty inches, is equal to two hundred and fifty-two grains, and four hundred and fifty-eight thousandth parts of a grain, of which as aforesaid the imperial standard Troy pound contains five thousand seven hundred and sixty."

Dr. YOUNG makes this explanatory remark:—"The slight discordance of the numbers of the successive years depends merely upon the adoption of a standard Troy pound better authenticated than the two pound weight particularly employed by Sir GEORGE SHUCKBURGH, which [former] was finally preferred, both as representing a unit, and as being more simple in its form than the two pound weight."

Notwithstanding this, the British authorities, both governmental and scientific, constantly cite the original value assigned by KATER for the weight *in vacuo* at 62° F. of the cubic inch of water (viz. 252.722 grains); while they nevertheless adopt the corrected weight of the act of Parliament of 1824, for the weight of air (viz. 252.458 grs., deduced from the corrected weight *in vacuo* above given, viz. 252.724 grs.), though the two are inconsistent with each other. Thus, in the Sixth Appendix to the Second Report (made in 1869) of the British Standards Commission of 1868, Mr. H. W. CHISHOLM, Warden of the Standards, says that "the legal weight in a vacuum of a cubic inch of water at 62° F., authoritatively and scientifically determined by SHUCKBURGH and KATER, is 252.722 grains." But he gives also, at the same time, the legal weight of the cubic inch of water in the air, under the conditions specified in the statute, precisely as given in the statute itself, as of course he was bound to do; though this is not the value given by SHUCKBURGH and KATER, nor is it deducible from their value for the vacuum, given by Mr. CHISHOLM as the proper one, immediately before.

SUPPLEMENT.

SECTION 1. — THE METRIC SYSTEM BEFORE THE NEW YORK UNIVERSITY CONVOCATION.

In proceeding to present here a summary of the principal facts and incidents of more recent date than those recounted in the foregoing essay, connected with the progress of metrological reform among the nations, it is natural to commence with a brief notice of the continuation of the discussion of the subject before the University Convocation, and of the final disposition of it made by that body.

As the University Convocation is an organization of which the character and objects are only imperfectly understood beyond the limits of the state of New York, a few preliminary words may not be out of place explanatory of its origin and constitution. The University of the state of New York is, itself, an institution which, as it has no parallel in this country, and no exact parallel abroad, holds a place in the educational system which it would be difficult in few words clearly to define. It consists of a board of twenty-three members who, under the corporate title of "The Regents of the University of the state of New York," have their head-quarters at the capital of the state (Albany), and exercise a kind of supervisory power over the secondary, superior, and professional education of the entire state. Over the colleges their right to exercise control is very limited, and does not reach at all the internal administration of those institutions. But it enables

them to exact from the colleges definite annual reports on their financial condition, their revenues and expenditures, their organization, their educational operations and the statutes and by-laws by which they are governed, in such form and with such detail as the supervisory body choose to prescribe. The Regents are invested with the power of conferring degrees, but they do not examine for graduation, and they use their power only in bestowing occasional honorary distinctions. From the nature of the case, therefore, the Convocation of the University of New York is a very different body from the Convocation of the University of Oxford, or that of the University of Cambridge. In a British University the Convocation consists of the graduates of the University, and is the highest legislative body. The University Convocation of New York is composed of the presidents, professors, and other officers of instruction of all the colleges of the state, and of the principals and teachers of all the academies, or schools of secondary education, and possesses no distinctive powers at all. Its business is to discuss educational questions with a view to secure, if possible, concurrence of opinion and harmony, if not uniformity of practical methods. Its secondary design is to stimulate educational zeal, and, by the personal intercourse between its members which it facilitates and encourages, to promote a kind of *esprit de corps* among the numerous educators of the state. The University Convocation was called into existence by an invitation addressed in 1863 by the Regents to the college officers and other teachers of the state. It was organized in August of that year, and has held annual meetings ever since. It embraces at present not only the instructors, but also the trustees, of the several educational institutions subject to the visitation of the Regents.

From the composition of this body it is obvious that its power to influence public opinion must be very great. To have secured from it, what at first seemed to be probable, an expression of approval of the movement, then in its infancy in this country, in favor of metrological reform, and especially in favor of the introduction of the metric system among us, would have been an important point gained. To have been successful in inspiring it with a positive zeal, and in enlisting its members in an active coöperation in furtherance of the movement, would have been to create

one of the most powerful instrumentalities which could be devised for advancing the cause of the reform. Carry the metric system into the schools of the country, let a rising generation be once made thoroughly acquainted with its nature and its advantages, and the voice of the obstructionist will be heard in the land from that time forward in vain. It will, of course, continue to be just as impossible as we are told it is now, and told by a great many weighty authorities — public functionaries with imposing titles before their names, and no end of honorary distinctions after, and private citizens of influence, accustomed to dictate opinions each to the little social world around him — it will continue to be just as impossible as it is now to substitute a new set of measures for an old one; but it will be done all the same, and nobody will be frightened for fear the sky should fall.

Next to a direct and zealous coöperation, the course actually pursued by this important body toward the metrological movement was, perhaps, the most advantageous to its interests which they could have taken. A resolution of languid and half-hearted approval, adopted at the first suggestion, would have put the matter out of sight, and by consequence speedily out of mind. Its reference to a committee for inquiry and future report, and especially to a committee of uncertain views which proved eventually to be unfriendly, the extraordinary protraction of the deliberations of the committee, the presentation from it of two successive reports, — the first oral, and the latest argumentative and written, and subsequently published,— served to keep the matter before the Convocation for several successive years, and to prepare the members to listen with greater interest to the lively discussion which the published report was destined to provoke.

The written report was presented at the meeting of the Convocation held in 1870. It was accompanied by resolutions, the general purport of which was to discourage further effort to introduce the metric system, but of which two are remarkable enough to deserve reproduction here. The second resolution was the following: —

"*Resolved*, That the committee on coinage, weights and measures [this same committee] be requested to publish their report to this Convocation, with such additions as they may deem necessary,

in connection with the report of John Quincy Adams on weights and measures, made to the House of Representatives in the year 1821, and the lecture of Sir John Herschel on "The Yard, the Pendulum, and the Meter," to the end that the whole subject may be more fully discussed, considered, and understood."

And the sixth resolution was this: —

"*Resolved*, That the committee on coins, weights and measures be, and they are hereby authorized to ask the attention of the Government, and of all associations for the advancement of science and knowledge, to the expediency of changing the value of the ounce troy, and thus substituting a single weight for the three — avoirdupois, troy, and apothecaries' — now in use."

The first of these two resolutions had an ulterior object beyond what appears. Apparently the design was merely to fortify the committee in their positions by the presumedly high authority of Adams and Herschel; but along with this, on the part of the author, was the desire to swell the report to the dimensions of a volume, to be thrown upon the market at a moment when the newly-awakened interest in the subject would be certain to secure for it a remunerative sale. This volume accordingly appeared very promptly, with the imprint of A. S. Barnes & Co., of New York and Chicago, in its title-page, and copyrighted. And, as if it were not sufficient to allow the work to make its way upon its own merits, a copy was placed, under authority of the legislature, and ostensibly in the interest of public education, in the library of each college and academy of the state.

The second of the resolutions cited formulates distinctly the proposition of the committee, briefly noticed on page 83 of the foregoing address. The reasoning of the committee which is there referred to is based upon an arithmetical blunder so extraordinary and so absurd that it is quite impossible to trace it to its probable origin. The difference between the ounce troy and the ounce avoirdupois is there stated to be the "eighty-three thousandth part (of the former) very nearly." It was at first supposed that this was merely an erroneous mode of reading the decimal value of the difference between these two weights; for this difference, which, in the form of an ordinary fraction is $\frac{4 2 5}{4 8 0 0}$ths of a troy ounce, is, decimally, 0.088+ oz., or more than eighty-eight one-thousandth

parts. An error in division might have made this 0.083 oz., and this erroneously read might have been expressed as one eighty-three thousandth part, instead of eighty-three one-thousandths. But two such singular blunders could hardly be conceivably attributable to a professor of mathematics, the author of a whole series of elementary treatises on the different branches of his science, who had devoted the whole of a protracted life to the training of others to exactness.

If the difference between the troy and avoirdupois ounces had been what the committee stated it to be, it would have amounted to the $\frac{1}{17\frac{1}{3}}$d part of a grain, or 0.00578 gr. ($=\frac{3}{8}$ of a milligram), and would have been totally imperceptible in all ordinary transactions. It is perfectly incredible that the committee should have supposed they had to deal with only such a trifle as this in making a proposition of reform and improvement in a manner so solemn, and asking an equally solemn resolution in its favor from the Convocation. On the other hand, if the committee had any conception of the real magnitude of the difference they were talking about, it argues a singular inconsistency in them to propose a new grain of the value of $\frac{17}{32}$ds of the old grain, or 0.885 gr. for weighing gold and gems, and salutary or poisonous drugs, at the very moment in which they are deprecating all change, on the ground of the confusion it will bring.

The report of the committee having been published, with the name of a professor of Columbia College as its reputed author, there followed the action of the board of trustees of that institution, as recounted in the foregoing address, and the presentation of the address itself to the Convocation, at its next ensuing meeting in August, 1871. The length of the address was too great to allow it under the rules to be read before the Convocation entire. As a consequence of this, the portion in which the objections of the committee were passed in review failed to come directly before the body. This afforded an opportunity to the chairman of the committee to make what he regarded as an effective point, viz., that while a great many words had been uttered, not a single position of his had been shaken; not a single difficulty met. The writer of the address rejoined by declaring that there was not one of these points that he had failed to meet, and by offering, with

the leave of the Convocation, to continue and dispose of them all on the spot. This was not granted, but an order was taken (which was never carried into execution) to print, forthwith, the proceedings of the Convocation (usually delayed in publication for more than a twelve month, in order to appear as an appendix to the annual report of the Regents), and along with them the address entire.

The Convocation, moreover, in order to afford the committee an opportunity to reply to the strictures of the address, recommitted the whole subject to them, and postponed the further discussion until the following year. By some it was supposed that a more careful inquiry, resulting in a better understanding of the subject, would induce the committee to modify in some degree their previously presented arguments and conclusions, and to endeavor to effect a graceful retreat from their untenable position. This anticipation proved to be quite mistaken. The committee devoted themselves during the recess very industriously to the gathering of statistical information in regard to the use of weights and measures — especially of measures — in manufactures; and they prepared a very elaborate report, setting forth in detail many of the particulars thus gathered. The argument is one with which the country, from many repetitions, has become very familiar. It is simply: "You will have to change all these things, and it will be very inconvenient to do so." Considering that the opposing argument, when reduced to its most compact form, is simply and very justly: "It will, all things considered, be a great deal more inconvenient, in the long run, not to do so;" a more particular account of this report is unnecessary here. The report presented the following, as the conclusions of the committee: —

"1. Considering the intimate relations between words and things, and that by use in their elementary forms they become almost identical, we deem it unjust to a people to take from them, by law, the simple language of number and quantity to which they are accustomed, and to substitute therefor the cumbrous phrases of a foreign tongue.

"2. Considering the great changes and confusion which the introduction and exclusive use of the metric system would produce in our language, in our elementary ideas of number, in our domestic

trade, in our deeds of record, and in the mechanic arts, we should deem such introduction a public misfortune.

"3. Considering that, by the comity of nations, each should not be insensible to the common interests of all, we commend the liberal spirit of legislation which has placed the metric system on the same footing as our own, and deem that this is all which its friends have a right to ask."

[In regard to the assertion of this last proposition, viz., that the legislation of our country "has placed the metric system on the same footing as our own," it may be worth while, since we hear the same assertion very often repeated, to remark that this is simply not true; nor will it ever be true until the government itself shall, as the friends of the system demand, make use of the system in all branches of its service, just as frequently and as freely as it uses that which is here called "our own."]

The committee consisted of three members, — Prof. Charles Davies, Regent Robert S. Hale, and Prof. James B. Thomson. The report of 1870 was prepared and presented without any consultation with Prof. Thomson. The report of 1872 was prepared in like manner. As Prof. Thomson's views were known to be at variance with those of the chairman, the neglect, certainly in the latter instance, could hardly have been without design. The day appointed for the meeting of the Convocation in the latter year was Tuesday, August 6th. Precedent had established the rule that its sessions should continue during Tuesday, Wednesday, and the morning of Thursday. Precedent had also established that this last morning should be mainly occupied with meetings in section, — the "College Section," and the "Academy Section," sitting separately. The time for business in general session was therefore limited almost wholly to the first two days, the joint session of Thursday ending at ten o'clock, A.M. Under these circumstances it was exceedingly desirable that the report of the committee on metrological reform — immensely the most important of all the subjects before the Convocation — should be presented early; and the executive committee, to whom it belongs to arrange the order of the exercises, were urgently requested by the friends of progress to place this subject among the first to be called on the first day. They were informed, in reply, that this could not be done, the chair-

man of the committee on weights, measures, etc., having written to give notice that he should not be present until Wednesday, nor ready to present his report until the afternoon of that day.

The report, however, had been for some time complete, and Prof. Thomson, of the minority, who had asked to be permitted to examine it, had been informed that he could have an opportunity of doing so by visiting, during the week preceding the meeting, the chairman at Saratoga, where, according to his annual habit, he was spending a portion of his summer. On receiving this intimation, Prof. Thomson repaired to that favorite watering-place, but by a singular succession of seemingly, but, perhaps, not wholly fortuitous incidents, he failed to find the chairman at his rooms or elsewhere until within less than two days before the time appointed for the meeting. He had prepared a minority report, but, under the circumstances here detailed, it had been drawn up as an independent argument, and without any reference to the reasonings or conclusions of the majority. This report concluded with the following resolutions: —

"WHEREAS, the commercial, diplomatic, and scientific intercourse between different nations is widely extended and rapidly increasing; and, whereas, international intercourse, heretofore seriously impeded by the irregularities and imperfections of our own and other systems of weights and measures, would be greatly facilitated by a common system in which all quantities of exchangeable commodities, scientific experiments, and statistical information, might be expressed; therefore,

"*Resolved*, That in the judgment of this Convocation, measures should at once be taken by the friends of commerce to establish a uniform system of metrology for the use of the civilized world.

"*Resolved*, That, in order to be acceptable to the great family of nations, and fulfil the great objects of its mission, said system should be founded upon an invariable standard and the decimal notation, that its base units should be commensurable with each other and be expressed in simple, concise terms.

"AND, WHEREAS, the metric system, by common admission, combines these elements in a higher degree than any other system reached; and, whereas, this system has already been adopted by so many enlightened nations; therefore,

"*Resolved*, That we earnestly recommend its substitution for our own system as soon as the people can be prepared for the change.

"*Resolved*, That the quickest and best way to familiarize the people with its principles and applications is to teach them in all our public and private schools, and in connection with the present system, to begin to practise them in ordinary traffic, in competitive examinations for the civil service, in the requirements for entering college, scientific schools, the naval and military academies, etc."

The following resolutions, prepared by the author of the foregoing address, were also laid before the Convocation: —

"'WHEREAS, in order to the facilitation of intercourse between nations, whether the same be commercial, postal, diplomatic, literary, or social, it is eminently desirable that the quantities of all exchangeable commodities, and all quantities whatever which there may be occasion to mention in communications, written or oral, should be expressed in the denominations of some common and universally accepted system of weights and measures;

"AND WHEREAS the metrological system of which the basic unit of length, called the meter, was definitely and permanently fixed by the International Scientific Commission assembled for the purpose in the city of Paris, in the year 1799, has been adopted and established by law as the exclusive system according to which quantities are to be legally expressed in the transaction of business, by nearly every people having intimate and extensive commercial relations with the United States, except the British;

"AND WHEREAS, indications too significant to be disregarded point to the probability that the same system will, at no very distant day, be established by law in the British Islands, as it has been already in their vast East Indian dependencies;

"AND WHEREAS, it becomes every nation claiming to be enlightened, to coöperate with sister nations in the furtherance of a reform of so signal importance, and so pregnant with benefits for the whole human race; therefore,

"*Resolved*, As the sense of this Convocation, that effectual measures ought to be taken, with the least possible delay, by the Congress of the United States, by the several state legislatures, and

by educational institutions throughout the country, to acquaint the people of the United States, and all the people, with the nature and merits of the metric system of weights and measures, with the extent to which the said system has already been adopted by law, and brought into actual use, and with its claims to be universally accepted and made the metrological system of the world; and, to this end,

"That laws should be made by Congress, providing that, in the levying of import duties upon foreign goods entered in our custom houses, quantities shall be stated in the denominations of the metric system;

"That the tariff of postal charges levied upon matter transmitted through the mails of the United States should be revised and reconstructed upon a plan in which the limit of the weight of matter transmissible under such postal charge shall be expressed in metric denominations;

"That a law should be enacted by Congress requiring that in the returns of the decennial census of the United States, in documents issued by the Bureau of Statistics in Washington, and in all papers proceeding from the executive departments of the Federal government where quantities are mentioned, such quantities shall be stated, not only in the denominations of weight and measure now in legal use, but also in equivalent metric values; and, finally,

"That the legislatures of the several states should pass laws requiring that in all universities, colleges, academies, normal schools, and common schools, established by their authority, instruction in the nature and use of the metric system shall be given, and that the principles of the said system shall be taught to every pupil.

"*Resolved*, further, that a copy of the foregoing preamble and resolutions, duly attested and signed by the proper officers of this Convocation, be transmitted to the President of the United States, with a request that the same be communicated to Congress; and that copies, similarly attested and signed, be sent to the governors of the several states of the Union, with the request that they be laid before their respective legislatures."

The chairman of the committee remained at his summer retreat, within an hour's distance of the Convocation, until shortly before

the adjournment of the morning session of Wednesday, the second day; and it presently appeared that his delay had been with a design to force a vote upon the resolutions appended to his report without debate. He made the proposition that the two reports should be successively read, — a reading likely, nearly or quite, to exhaust the time of the afternoon session; that thereupon fifteen minutes should be allowed to Prof. Thomson, fifteen minutes to his associate of the majority, and five minutes to himself, — all being members of the committee; after which the question should be immediately taken, no member of the Convocation not of the committee being permitted to express his views. Somewhat incautiously, Prof. Thomson assented to this arrangement, provided he might be allowed to give up his time to the present writer, — a proposition which, when made, was promptly refused. This writer protested against the pretension of the committee to impose a gag-law upon the Convocation, and demanded, for himself, and for every other member, full freedom of discussion of the important question in regard to which that body was about to be called to put itself on record before the world.

Accordingly, immediately on the completion of the reading of the minority report, the writer rose, and moved that the resolutions before the Convocation, under a suspension of the rules, if necessary, be made a special order till finally disposed of. This motion was vehemently opposed by the chairman of the committee, who denied to the originator of the motion the right to speak on the subject, on the ground that he had had ample opportunity to present his views on the previous year, and that there remained nothing on that side to be said. To this the writer rejoined that the facts of the case were otherwise; that he had *not* had the opportunity to present his paper on the previous year, except in part; that the proceedings of the Convocation containing that paper had not yet been published; and that, though the paper had appeared in independent form, it had not been seen by the members of the Convocation, who had, nevertheless, been supplied by law with copies of the committee's original report and its formidable appended documents; that the subject was very far from having been exhausted, and that the Convocation had no moral right to commit themselves upon it until after they had heard it thoroughly discussed; more-

over, and finally, that inasmuch as this question had been earnestly and carefully considered by deliberative bodies of the highest character, too numerous to be separately mentioned, in every civilized land, and among non-metric peoples, as well as metric; by royal, imperial, and national academies, by associations for the advancement of science, by international, statistical, and monetary conferences and congresses, by educational conventions, by chambers of commerce, boards of trade, societies of engineers, and many other organized bodies of the highest authority, to say nothing of innumerable institutions of learning in our own and other countries; and inasmuch as these had, one and all, without as yet a single known dissenting voice, declared themselves in favor of the universal adoption of the metric system of weights and measures, it would become this Convocation to consider very long, and reflect very seriously, before taking the course which the chairman of the committee seemed confidently to expect them, and was evidently bent on driving them, to take, — that of recording themselves as the single and solitary body of presumedly enlightened men who were bold enough to take the opposite position, and set themselves up against the otherwise unanimous voice of enlightened mankind.

The shades of evening fell before this discussion was concluded. It ended without pressing the motion to a vote, in the tacit consent of the Convocation to allow freedom of debate, and to give as much time to the discussion as the indispensable business remaining before the Convocation would permit. The assembly then adjourned to meet later in evening session.

On the reassembling of the Convocation, it appeared that the tactics of the committee had been changed. With the assent of the Convocation to the demand for free discussion, the prospect of carrying the propositions of the committee had become evidently more than doubtful, while the possibility that the resolutions of the minority might succeed had ripened into a probability. The great body of the assembly had been hitherto silent listeners; the active men on either side were few. Many plainly were so far undecided as to prefer not to be compelled to vote. In this state of things — in the moment when the debate would otherwise have opened — a member of the committee rose and offered the following resolu-

tion, which it was thought unadvisable to oppose, and by the adoption of which a test vote was avoided: —

"*Resolved*, That the time assigned by the Executive Committee to the discussion of the report of the Committee on the Metric System of Weights and Measures being inadequate to the full consideration of that subject, the report lie on the table until the next annual meeting of the Convocation, and that the report of the committee, and the minority report, be both printed."

At the next annual meeting of the Convocation this writer was absent from the country, but the Committee on the Metric System were all present, and Prof. Thomson was prepared to vindicate the views of the minority. The majority, however, had wholly lost heart, and, on their own motion, the subject was postponed indefinitely.

This history has been given in some detail, because it is a history of the most protracted and determined struggle which has taken place over the metric question in this country, and because it possesses a more than common interest, derived from the arena in which it was held. It was no slight discouragement to the friends of metrological reform, that the assembled educators of the great state of New York should have once pronounced against them. And it was a corresponding encouragement when that body, after taking the subject a second time into consideration, were found to be in a frame of mind in which they could not be safely pressed to reaffirm their former action. It was judicious, for the time being, to leave the matter there. The educators of New York are, beyond a question, largely with us to-day.

Section 2. — LEGISLATION FAVORING THE METRIC SYSTEM.

The foregoing essay contains an account, complete, so far as information had been obtained up to the date of its delivery in 1871, of the progress which had been made in extending the use of the metric system among the nations, by favoring legislation. During the few years which have since elapsed, the work has been by no means at a stand-still. It has, on the contrary, advanced, especially on the continent of Europe, with a rapidity which could hardly then have been anticipated. Of the continental countries, for example, the only ones in which the system had at that time been adopted in full were France, Belgium, Holland, Spain, Portugal, Italy, Greece, and Roumania. Switzerland had adopted metric values, and of the German states, some had done the same; and others, including all which had been members of the Zollverein, together with Austria, had adopted the metric pound of 500 grams, — a weight-unit which had also been received and established in Denmark. Some, as Sweden and Norway, had decimalized their measures of length without changing the basic unit; and some had adopted metric bases of the values of 250, 300, and 500 millimeters, under the name of *foot*. Prospectively, the system had been adopted in full by the states north of the Main, known as the North German Confederation, to go into effect on the first of January, 1872. Finally, Turkey had adopted a metric value of 75 centimeters for her unit of length. Such was the state of things on the continent of Europe in 1871. Immediately, however, upon the consolidation of all the states of Germany under one political head, the law previously applicable to the northern states only was extended over the entire empire, and came generally into full effect on the previously appointed date, — 1st of January, 1872, — and universally, 1st of January, 1875. Turkey, at the date of the foregoing address, was only known to have so far favored the metric system as to have adopted a metric value for her unit of length. She had, however, already made provision for the future introduction of the system, entire, throughout the empire, the use to be optional from March, 1871, till March, 1874, and after this latter date compulsory.

In 1871 a law of the Austrian Empire was promulgated, making the use of the metric system compulsory throughout Austria after the 1st of January, 1876. Two years later a similar law of the Hungarian Diet extended this provision to Hungary; so that at the present time no other system is legal throughout the Austro-Hungarian territory.

In Sweden, the system, according to existing law, will come into *full* and exclusive use on the 1st of January, 1883. She has used metric weights in her coinage since 1873. Norway has anticipated Sweden in her action. We have not at hand the form of the law by which the metric system has been established for that kingdom, but a communication from Mr. Ch. Christopherson, United States Deputy Consul at Christiania, addressed to the State Department of the United States, at Washington, under date of February 4, 1877, makes the following interesting statements: —

"The new law concerning coin in Norway, based upon gold, became valid from the 1st of January this year. All public, and most private, accounts are, therefore, now kept in the new standard of coinage, — 1 krone = 100 ore (4 krones = $1.07), the value of which is equal to the weight of $\frac{2}{62}$ oz., or 0.40323 gram pure gold.

"From the first of January next year, also, the now ruling weights and measures will cease to be recognized, and the Metrical French System adopted."

Denmark has had the metric pound of the German Zollverein in permissive use since 1852, and in obligatory use since 1863. Like Norway and Sweden, she has recently adopted metric weights in her coinage. The introduction of the metric system in full into this small kingdom cannot now be long delayed. A proposition to that effect was introduced into the Rigsdag, in 1876. It is not known as yet to have been acted on; but a people so comparatively small, completely surrounded by metric neighbors, must inevitably become metric in practice, whether they are so by law or not.

From what has been said, it will appear that the metric system of weights and measures has been established by laws which, except in the single case of Sweden, have already taken effect as the only system permissible in the transaction of business, throughout all Europe, with the exception only of Russia, Denmark, and the

British Islands. Nor has the government of the great Empire of Russia shown itself indifferent to the progress of a reform which has spread itself so rapidly and so far, and with which it now finds itself in contact along its entire western border. In the winter of 1876–7 an imperial commission was despatched to Paris to make inquiry into the practical results of the metric legislation of central and western Europe, with the view, in case of a favorable report, of instituting a similar reform at home. The report was favorable, but unfortunately the attention of the government had in the meantime become absorbed with the very grave question of peace or war, and this important subject has been, for the time being, lost to sight.

In England the friends of the metric system have been by no means inactive during the last six or seven years, but their efforts have not as yet been successful in procuring any additional favorable legislation. During the session of Parliament in 1873, Mr. J. B. Smith, the originator of the bill of 1871, enjoining, after a limited term of years, the exclusive use of the metric system throughout the United Kingdom, — a bill, which, by so slender a majority, failed to pass, — brought forward his measure again; but a number of influences conspired to make the occasion inopportune, and the bill was not pressed to a vote.

A letter from Prof. Leone Levi, the Secretary of the permanent committee of the British Association on the metric system, to Melvil Dewey, Secretary to the American Metric Bureau, dated May 24, 1878, says: "Her Majesty's Government have introduced a bill in the House of Commons for the consolidation of the law on weights and measures, which not only reënacts the permissive use of metric weights and measures in contracts, but provides for the verification of metric weights and measures used for manufactures and science. The board of trade has now obtained standards, and we hope that in time the use will also be permitted for trade."

In the United States, after the manifestation of a long-continued indifference toward the measure on the part of our public men, no less remarkable than the zeal in its advocacy of its friends in private life, we had at length the satisfaction of having secured in the 44th Congress a committee in the House of Representatives, in substantial sympathy with this important movement. The chairman

of this committee was, as in the 45th Congress he continues to be, the Hon. A. H. Stephens, of Georgia, well known for his enlightened and liberal views upon all great questions of social and political interest. The majority of the committee were also believed to be favorable to some active measures of legislation looking to the introduction of the metric system into our public service, at least, if not into general use throughout the country. Unfortunately the state of health of Mr. Stephens was such as to prevent his attendance on the first session of the Congress, and the committee naturally postponed action in the hope of his arrival and participation with them. In the meantime petitions from a variety of quarters, among the rest from the American Metrological Society, were laid before Congress, and on the 9th of May, 1876, Mr. Sayler, of Ohio, acting as chairman of the committee in the absence of Mr. Stephens, presented in the House of Representatives the following resolution, which, under objection to its immediate reception, was laid over: —

"*Resolved*, That the heads of the executive departments of the government be, and they are hereby, requested to report to this House, at as early a date as practicable, what objections, if any, there are to making obligatory in all governmental transactions the metrical system of weights and measures, whose use has been authorized in the United States by act of Congress, and also how long a preliminary notice should be given before such obligatory use can be introduced without detriment to the public service; and that they are also requested to state what objections there are, if any, to making the metrical system obligatory in all transactions between individuals, and what is the earliest date that can be set for the obligatory use of the metrical system throughout the United States."

The subject did not come up again before the close of that session. During the second session of the same Congress, the public attention was so wholly absorbed with the great presidential contest of 1876, and with the excitements growing out of the disputed count of the electoral vote, — excitements in which both Houses of Congress equally participated, — that it was impossible to make any progress with a question like that of metrological reform, which, however great its importance, could not be pressed as one of imme-

diate urgency. It was, therefore, not until the called session of the 45th Congress, in the autumn of 1877, that the resolution above referred to, as originally presented by Mr. Sayler, was, on motion of Mr. Clark, of Missouri, reintroduced and finally adopted. In response to the interrogatories addressed in this resolution to the several executive departments, replies were returned, some with remarkable promptness and some only after an interval indicative of mature deliberation and reflection. The latter class of these replies was, on the whole, favorable; the former, on the whole, the reverse. It was a difference which might naturally have been anticipated from the evidence furnished by the replies themselves, as to the amount of thought which had been bestowed upon the subject by their authors. The unfavorable replies presented merely the every-day objections to the metric system with which the public are so familiar. The favorable were favorable rather as showing the convictions of their authors that the proposed change is desirable, than their belief that it is easily practicable. The writers seem satisfied, nevertheless, that the change must come at last, but hold out little encouragement to the hope that it can come early. Indeed, the replies of both the classes here distinguished seem to manifest a disposition to magnify difficulties to an extent which we should hardly have looked for in men of the enlightenment which we justly expect to characterize the high officers of any government. A synopsis is given in another place of the most important points made in these several responses.

In anticipation of these replies, many of which were only transmitted to Congress late in March, the committee forbore to press matters of legislation; but on the 29th of January, 1878, a bill was introduced into the Lower House, providing for the introduction and use of the metric weights and measures into the custom-house service, which was read twice, referred, and ordered to be printed. It is probable that before the close of the second session of this Congress, which, at the time of the present writing, is yet future, there will be some effort made to test the sense of Congress as to this measure, by putting this bill upon its passage. At the close of the first session it appeared that there had been presented to Congress a very large number of petitions, asking for action on this subject, some of them praying for the enactment of a statute

providing for the introduction, after a time in the future to be now definitely fixed, of the metric system to the exclusion of every other, throughout the whole country; others demanding only such legislation as, by requiring its adoption in certain branches of the public service, might gradually make it familiar to the people, without requiring its general use. It is believed by this last class of petitioners that the progress of this reform in our country will have to be gradual; and that the time is not yet come when we can with propriety insist upon so sweeping a measure as that which proposes to make, even though prospectively, the use of the system compulsory among our entire people. No one doubts, on the other hand, that the introduction of metric weights into the post-office and the custom-house would be universally acceptable, and would lead in time to such general familiarity with them as to make their subsequent introduction into common use easy. In several countries in Europe this has been the progress of legislation. All Germany was familiarized with the metric system by the introduction of the metric pound into the Zollverein. It was only after this measure had been long in force that the system was made general in Germany. The same has been true of Austro-Hungary; and at the present time Denmark, which has not adopted the metric system generally, is employing, for *all* purposes, exclusively the metric pound.

Metric weight in our post-office would be to a slight extent advantageous to the public who use the post-office, since it would increase the postal unit by about one-seventeenth part. Metric weights and measures in the custom-house would be advantageous to importers who are in communication with metric countries; and hence the sentiment in all commercial seaports has been found to be strongly in favor of this modification of the law. It appears, from a communication of Mr. Upton, Chief Clerk of the Treasury Department, printed among the replies to the committee of the House of Representatives, that the imports of the United States from metric countries during the year ending June 30, 1877, amounted to nearly $200,000,000, and that the exports from the United States to such countries were of about equal amount. The imports from Great Britain and the British possessions, and from other countries not employing the metric system, were something

greater, or about $300,000,000; but two-thirds of this amount was from Great Britain and her colonies, where the measures of capacity are entirely different from ours; so that not more than $100,000,000 of the total can be considered as representing merchandise measured by our own system. If Congress were only to enact that duties on invoices from metric countries should be estimated according to a metric scale, this alone would reduce the labor of importers and of the custom-house officers in calculating duties by not less than one-half.

The introduction of metric weights into the coinage is a matter still more simple, and one which has been urged upon Congress by numerous petitions during the past twelve or fifteen years. In point of fact the silver subsidiary coinage now in circulation was made metric by the act of Congress of 1873; and the nickel five-cent piece was made metric both in weight and diameter, by an act passed in 1866.[1]

But the point which the friends of the system have been most urgently pressing is the change of the weight of our gold coins so as to make them conformable to the metric system. The change would be so slight as for ordinary purposes to be imperceptible; and as it respects most of the coins would be within the limits of tolerance allowed for variation of weight by the coinage acts.[2] The

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[1] The dimensions were left by the act to be determined by the Director of the Mint, and the diameter was fixed by him at two centimeters. When the new coinage act of 1873 was under consideration, Mr. A. Loudon Snowden, chief coiner of the Philadelphia Mint, proposed to enlarge the diameter to twenty-two millimeters, and to coin a two-cent piece of three centimeters and a one-cent piece of one and a half centimeters; but these provisions failed of adoption. Though the die of the five-cent coin has never been altered, the new Director appointed under the act of 1873, Dr. Linderman, was accustomed to state its diameter to be sixteen-twentieths of an inch.

[2] The gold dollar contains 25.8 grains troy, nine-tenths fine; or of pure gold 23.22 grains. The metric equivalents of these values are 1.672 grams and 1.5048 grams. Thus the pure gold in the United States dollar exceeds a gram and a half by only 4.8 milligrams, which is about three-tenths of one per cent.

The metric dollar, as proposed for the United States, and as already established in the Argentine Republic and in Japan, contains 1.5 grams or 1½ grams pure gold exactly. With the addition of alloy in the proportion of one part of base metal to nine parts of gold, the weight of the metric dollar, or of the *peso duro* of the Argentine Republic, or of the *yen* of Japan, is 1⅔ grams. Calling one-third of a gram a *tergram*, the metric dollar contains five tergrams.

Argentine Republic has adopted a unit of value — the *peso duro* — equivalent to our dollar, expressed in a metric weight; and the Empire of Japan has adopted a similar unit called the *yen*. Such a change in our gold coin would be the first step toward the creation of an international coinage, such as sooner or later is sure to be accepted, founded upon a metric basis. The extent to which the metric system has been actually introduced among different peoples up to the present time is shown in the following table, where the date of legislation and of adoption in full, and the population of the countries which have introduced it, are severally given: —

PREVALENCE OF THE METRIC SYSTEM.

STATEMENT AS TO THE EXTENT TO WHICH THE METRIC SYSTEM HAS BEEN INTRODUCED AMONG DIFFERENT PEOPLES, WHETHER BY COMPULSORY OR BY PERMISSIVE LEGISLATION.

I. *States in which the Metric System is obligatory by law.*

[In some cases, as in the South American States, in Turkey, and in Egypt, the compulsory legislation is imperfectly enforced among the people, but the system is employed in the custom houses and other business of the governments.]

States.	Original Legislation.	Obligatory Effect.	Population.	Remarks.
Argentine Confederation .	1863	1873	1,876,435	Imperfectly enforced, except in government business.
Austro-Hungary	1872	1876	35,904,435	German names allowed.
Belgium	1816	1856	5,387,105	Old names used before 1836.
Brazil	1862	1873	11,780,000	Diamonds sold by old weig't.
British India	1871	1871	190,277,654	Time of obligatory effect indeterminate.
Chili	1848	1863	2,166,000	From 1848 used for coin.
Costa Rica	1857	1858	165,000	Imperfectly enforced, except for government business.
Equador	1856	1866	1,784,741	All measures inspected and verified biennially.
Egypt	1875	1875	5,203,000	In use previously for coin.
France	1793–5	1840	36,102,821	A provisional system, 1793; system fully organized, 1795; a "systeme usuel" allowed, 1812; complete system enjoined, 1837, and made obligatory, 1840.
French Colonies	"	"	5,215,631	
Germany	1868	1872–5	41,060,695	In use previously in a number of states.
Greece	1836	1836	1,457,894	Common names allowed.
Guatemala	1857	1858	280,000	Imperfectly enforced, except for government business.
Italy	1861	1863	26,801,154	In some states adopted previously.
Carried forward . . .			365,462,565	

States.	Original Legislation.	Obligatory Effect.	Population.	Remarks.
Brought forward . . .			365,462,565	
Mexico	1857	1862	9,611,838	Not yet universally in use, but fast gaining ground.
Netherlands	1816	1821	3,716,002	Old names used till 1870; after that optional for 10 years.
Dutch Colonies	"	"	22,591,461	
Norway	1877	1878	1,763,000	Reform movement begun only in 1875.
Peru	Before 1850	1869	3,417,000	Imperfectly enforced, except in government business.
Portugal	1852	1862	3,990,570	Obligatory in Lisbon from 1860.
Roumania	1864	1866	4,605,000	Imperfectly enforced, except in government business.
Spain	1849	1859	16,835,506	In some provinces obligatory from 1855; in all Spain from 1859.
Spanish Colonies	"	"	6,419,339	
Sweden	1876	1883	4,341,559	Permissive during 1881 and 1882.
Switzerland	1851	1857	2,669,247	A metric foot of 30 centimeters is used, and a metric pound of 500 grams.
Turkey[1]	1869	1874	37,369,000	Optional from 1871.
U. S. of Colombia	1853	1854	2,794,473	Coin metric from 1848. System compulsory only in government business.
Uruguay	1862	1867	454,478	Imperfectly enforced, except in government business.
Venezuela	1857	1873	1,784,194	Imperfectly enforced, except in government business
Total			487,825,232	

II. *State in which Metric weight is obligatory by law, but not Metric measures of length, surface, or capacity.*

State.	Original Legislation.	Obligatory Effect.	Population.	Remarks.
Denmark	1852	1863	1,784,441	Danish coin metric since 1874.
Danish Colonies	"	"	127,401	
Total			1,911,842	

[1] The population of the Turkish Empire, as given, includes the tributary states as they stood before the Berlin Congress of June, 1878, with the exception of Egypt and Roumania.

III. *States in which the Metric System is permissive.*

States.	Date of Law.	Population.	Remarks.
Great Britain	1864	31,845,379	
British Colonies	"	12,139,087	
United States	1866	38,555,983	Census of 1870. Probably at present over 45,000,000.
Total		82,540,449	

IV. *State in which the Metric System is neither obligatory nor permissive.*

State.	Population.	Remarks.
Russia (proper)	65,704,559	The use of the metric system in the custom houses of the empire was ordered in 1870. In 1876, an Imperial Commission visited Paris to inquire into the results of the metrological legislation of western and central Europe, and reported favorably. A considerable number of societies have already adopted the system.
Russian Poland	6,026,421	
Finland	1,332,138	
Caucasus	4,893,332	
Siberia	3,428,867	
Kirgheez Steppes . . .	1,803,708	
Toorkistan	1,996,920	
Total	85,685,945	

SYNOPSIS OF LEGISLATION FAVORING THE METRIC SYSTEM.

[The following, which presents with a detail which the plan of the foregoing table would not allow the history of metric legislation, is extracted from the able and comprehensive paper prepared by Mr. J. K. Upton, Chief Clerk of the Treasury Department of the United States, to accompany the response of the Secretary of the Treasury to the resolution of the House of Representatives of Nov. 6, 1877.]

AMERICA.

ARGENTINE REPUBLIC. — (*Until* 1828 *with Uruguay.*) — The metric system of weights and measures introduced for customs purposes, according to the customs tariff laws of 7th October, 1872, and 11th October, 1873, and is used in the assessment of duties.

BOLIVIA, REPUBLIC OF. — (*Once South Peru.*) — Weights and measures the same as in Peru, which see.

The coin-weight, at least, since 1871, is the French gram.

BRAZIL. — (*Rio de Janeiro and Pernambuco.*) — Since January 1, 1874, the weights and measures of Brazil are the French metric.

An imperial decree of 26th June 1862, approved a law voted by both chambers upon the introduction of the metric system, which, after a permissive use of *ten* years, should be generally in force. According to a decree of 18th September, 1872, the new system went into obligatory effect with 1st July, 1873; a delay of half a year, however, to be allowed for the execution of the decree; therefore, with the first of January, 1874, the metric system is definitely established, with all its consequences, and since this time only metric measures and weights are used. Diamonds, however, are still permitted to be sold according to the old Portuguese *outava*.

The French meter has already for many years been commonly employed for manufacture, but often, as *now*, the English yard is used, and sometimes the old Parisian *aune*. Stone coal is sold, at wholesale, by the English ton of 2,240 pounds, avoirdupois,—the *tonelada*,—reckoned equal to 70 arrobas, old weights; so, also, bone ashes; also, ships' freights are, for the most part, settled according to the English ton.

The interval from the date of the decree of 26th June 1862, introducing the system, to that of 18th September, 1872, declaring the use of the system obligatory, is ten and one-fourth years; from the earlier date to 1st July, 1873, is eleven years, and to 1st Jan., 1874, the date from which its use is obligatory, eleven and one-half years.

CHILI, REPUBLIC OF. — (*Santiago de Chili.*) — A law of 29th January, 1848, introduced the French metric system of weights and measures. For coin-weight the system came at once into use, but for other purposes its enforcement was delayed.

By a decree of the President of the Republic, of the 31st May, 1862, and a decree of the administration of 19th December, 1862, the system came into force for customs purposes from 1st January, 1863.

The interval from the date of the law introducing the system, to its enforcement for customs purposes, was fifteen years.

In trade, and for the purposes of common life, the old system is generally employed.

Silk and woollen goods are sold by the *vera;* sugar by the *arroba.* Stone coal is sold by the ton (*tonelada*) of 1,000 kilograms; copper ore by the 100

kilograms; pig-iron is sold by the Spanish ton (*tonelada*) of 20 quintales (920 kilograms); so, also, is guano.

COLOMBIA, *in its broader sense.* — (*Republic of Colombia*, 1822 *to* 1831.) — The *three republics*, now constituting Colombia: —

1. United States of Colombia (formerly the confederation of New Grenada, until 1863; before that, the Republic of New Grenada, until 1858).
2. Equador.
3. Venezuela.

UNITED STATES OF COLOMBIA. — (*Bogota; Santa Fé de Bogota.*) — In conformity with the law of 8th June, 1853, the French metric system has been in force since 1st January, 1854 (including for shipping). For coinage the weight has been the French gram since 1848. This law introducing the metric system is still permissive for *private* persons, and is used at pleasure in their extensive business transactions. Consequently, in large transactions the old standards are also used.

ECUADOR, REPUBLIC OF. — (*Quito, or Francisco de Quito*). — According to the laws of 5th December, 1856, the metric system has been that of the republic since 15th October, 1866 (ten years). Since the last-mentioned date the metric system alone appears in *official* transactions.

A later law, that of 14th April, 1857, again orders the use of the metric system generally in all business transactions throughout the republic.

According to the law of 1856, once in every two years, on the 15th October, the weights and measures of each of the provinces, districts, and communes of the republic must be verified.

GUATEMALA. — (*Central American States; Guatemala, San Salvador, Honduras, Nicaragua, and Costa Rica.*) — In Guatemala and Costa Rica, since 1858, the French metric system is legally in force, and in San Salvador the French weight, at least for coin purposes, which also, in Honduras, since 1869, is employed as the coinage weight; but, in fact, in Guatemala and Costa Rica the old Spanish-Castilian system is in use, and controls, as well as in the other Central American States.

MARTINQUE. — (*A French Antilles Island in the West Indies.*) — French weights and measures (metric) legal, yet other systems are much in use, the old Parisian and the English.

MEXICO. — The weights and measures of the states of the republic are legally the French metric. A decree of President Commonfort, of the 15th March, 1857, ordered their introduction; requiring that *six months* after the date of the ploclamation they be exclusively used in all governmental transactions (which was not done), and from 1st January, 1862, should be obligatory for all the inhabitants.

The law of the 15th March, 1861, ordered anew the exclusive use, for all purposes, of the French system of measures, from 1st January, 1862, but this law appearing to remain almost without affect for private working, an imperial decree was issued in November, 1865, again declaring the use of this system alone valid (or in force) throughout all the States.

The use of the new system appears to be extending to more and more places, but least in the wholesale trade (1873), the old weights and ell-measures being still employed.

The new measures retain the names of the corresponding old, with the prefix "new."

PERU, REPUBLIC OF. — (*Lima.*) — The weights and measures of Peru are legally the French metric.

The introduction of the metric system has for many years been ordered, but as yet almost wholly without effect.

Later, in the year 1869, its adoption was again ordered; and for customs purposes it is in use. In general, the earlier or old Spanish-Castilian system, with some exceptions and peculiarities, is used. For coin-weight, the French gram (metric) is used.

UNITED STATES OF AMERICA. —The French metric system of weights and measures rendered permissive by law of 28th July, 1866. To the 5-cent copper nickel piece was given the metric weight of 5 grams (77.16 grains) [and the diameter of 2 centimeters] by law of 16th May, 1866. To the silver coins of the United States of smaller denominations than one dollar, were given metric weights, by the law of 12th February, 1873. For postal purposes, one-half ounce equals 15 grams, and so on in progression.

URUGUAY. — (*Montevideo.*) (*"Oriental Republic of Uraguay."*) — French metric system of weights and measures legalized by decree of 20th March, 1862. This system is in use for customs purposes, but for other purposes does not appear to have been brought into common use. It is employed to some extent for coinage.

VENEZUELA, REPUBLIC OF. — (*Caracas.*) — In the year 1872, through an executive order of 18th July of that year, the French metric system was introduced, in conformity with which already, since the beginning of the year 1873, entries for customs settlements are required to be made.

Coin weight is the French gram (metric), in conformity with the coin law of 30th May, 1848. The weights and measures have been *legally* for many years (about ten years prior to 1874) the French metric; but in practice the metric system had found no place, and even the customs tariff of 12th May, 1867, took the earlier system of weights and measures as its basis. According to a governmental decree of 17th September, 1869, the metric decimal system was to be brought into use in all the customs transactions of the republic, and likewise by the consuls of the state in certifying goods and manifests.

EUROPE.

AUSTRIA. — In conformity with the law of 23d July, 1871, the French metric system of weights and measures was made obligatory from the 1st of January, 1876. The interval from the date of the authorizing law to the date from which it was made obligatory was about four and a half years.

BELGIUM. — (*Antwerp.*) — The metric system of weights and measures was introduced with old denominations during the union of Belgium with the Netherlands; that is, by the law of 21st August, 1816, and the royal decrees of 29th March and 30th November, 1817. By a Belgian law of 18th June, 1836, these names were withdrawn and French names introduced. A law of 1st October, 1855, created from 1st January, 1856, the exclusive use of the French system (including also the French medicinal weight).

DENMARK. — The unit of commercial weight since the law of May 1, 1863, is the pfund of the 500 grams or the one-half kilogram. The unit of coin weight, in conformity with the Scandinavian coin convention of 18th December, 1872, and the law of 23d May, 1873, has been since 31st May, 1874, the metric gram; the convention to be in force until the end of December, 1884, ten years. The introduction of the complete metric system of weights and measures *is in prospect.*

On the 3d of October, 1876, the minister of interior recommended to the Parliament a project of a law according to which the use of the metric system of weights and measures was to be permissible for three years, after which its use should be compulsory throughout the kingdom. The coin weight under the coin law of 4th June, 1873, is the French metric, — the kilogram.

FRANCE. — The system of weights and measures known by common consent as the "metric system" was proposed by the Prince Talleyrand, then Bishop of Autun, in the year 1790. This system was declared the only system of weights and measures in France and in the French colonial possessions by the law of 1st August, 1793.

The organizing law for the new measures and coins of the metric system was adopted on the 7th April, 1795.

Under the organizing law of 7th April, 1795, and supplemental law of 15th August, 1795, money is reckoned since 1st July, 1796, and definitely since the coin law of March 28, 1803, in francs of one hundred centimes.

[The present standards were completed and deposited in the archives June 22, 1799.]

The metric system of weights and measures was definitely introduced through the law of 10th December, 1799; the organizing law, as before mentioned, bearing date 7th April, 1795.

For small or retail trade the "systeme usuel" was introduced and permitted through decree of February 12, 1812, and the order of the minister of the interior, of 28th March in the same year, and was allowed to continue in use until by the law of 4th July, 1837, its use was forbidden from 1st January, 1840. Although forbidden from this date, the "systeme usuel" was actually much in use as late as 1861.

The interval from the antecedent organizing (constitutive) law of 7th April, 1795, and the law definitely introducing the metric system of weights and measures into France of 10th December, 1799, is four years and eight months.

The interval from the decree of 12th February, and the ministerial order of 28th March, 1812, permitting the temporary use of the so-called "systeme usuel," and 1st January, 1840, the date from which its use was forbidden, is nearly twenty-eight years. (Twenty-seven and three-fourths years.)

The interval from the date of the law of 4th July, 1837 (interdicting or forbidding the use of the "systeme usuel" after the close of the year 1839), to 1st January, 1840, the date from which the use of the complete or pure metric system was made compulsory, was two and a half years.

GERMANY. — The customs pound (500 grams), the standard customs weight of the Customs Union, became the national weight on 1st July, 1858, throughout the greater part of Germany, and for a shorter time throughout the present empire.

It was also made the postal weight of the German Postal Union, and the railroad weight (for freight) of the Customs Union, and since February, 1852, the customs weight of the Austrian Empire, and through the Vienna coin treaty of 24th January, 1857, the coin weight in nearly all the German states, and also in Austria.

A decree relative to weights and measures for the North German Union was promulgated 17th August, 1868. This decree made the use of the metric system of weights and measures permissive from 1st January, 1870, and compulsory from 1st January, 1872. By a subsequent law of the German Empire, the same was reënacted and extended throughout the realm. Bavaria adopted it by a law of 29th April, 1869.

The interval from the date of the decree for the North German Union to the date when the use of the system became obligatory was three and one-third years; and from the date of the law of Bavaria to its compulsory use was two and two-thirds years.

In Rhenish Bavaria the metric weights and measures were introduced in the year 1840. Outside of the Rhenish provinces the system was non-metric until the metric system was declared optional from 1st January, 1870, and obligatory from 1st January, 1872.

In Baden, the weights and measures made commensurable with the metric system by law of November, 1810, came gradually into use, until by order of 21st August, 1828, their use was made compulsory with the year 1831, except as regards medicinal weights, which have been made metric from July 1, 1864.

In the Grand Duchy of Oldenburg, until the end of 1871, the system of weights and measures in different places differed. Only the metric *weight* by the law of 19th June, 1857, was made common from and after 1st July, 1858; an interval of *one* year. In Lubeck this weight was introduced later.

For *customs purposes*, the new *pound* (½ kilogram) and the centner (50 kilograms) have been used in all the States of the German Zollverein (Customs Union) since 1st January, 1854, divided, however, as to the

pound into thirty loth. From the same date the pound (½ kilogram), divided into thirty loth, was adopted by the German-Austrian Zollverein for *postal purposes.*

By a union of several of the German States the metric pound and centner were adopted in 1856. Since 24th January, 1857, the *coin pound* of 500 grams has been employed for the purposes of *coinage. Metric medicinal weight* has been in use since 1858.

GREAT BRITAIN. — The French metric system of weights and measures is permissive by law of 1864.

[For British India, see under Asia, below.]

GREECE. — (*Athens.*) — French metric system of weights and measures introduced by law of 28th September, 1836, but with the common Grecian names. In the Ionian Islands, however, the English weights and measures have been legalized since 1829.

HUNGARY. — The use of the new Austrian (metric) system of weights and measures was made permissive from 1st January, 1873, and obligatory from and after 1st January, 1876, an interval of three years. Article 8, of the law of 1874, provided for the introduction of the new metric system to be in force January 1, 1876.

ITALY. — Since the establishment of the Kingdom of Italy (17th March, 1861) the weights and measures are the French metric. This system has been compulsory over the *Italian* peninsula and Sicily since 1st January, 1863. It was introduced into Venetia (Venice) by the law of 11th March, 1869. It was introduced into Lombardy and Venice, when under the French dominion, in the year 1803, but came into permanent use only for governmental or administrative purposes. On the *island of Sardinia* it has been in legal use since 1st January, 1846; in Genoa since 1st March, 1847; in the rest of *Piedmont* since 1st April, 1850; in the *continental part* of the *former Kingdom of Naples* since 1st January, 1861. In the earlier *Papal States* its introduction was ordered, in 1848, to take effect from the year 1850, but prior to the end of 1870 has not been much employed.

In the former Duchy of *Parma*, since 1854, the Austrian (or German) customs-weight (the pound of 500 grams) has been employed for custom purposes. In *Leghorn* the metric weight for wholesale purposes has been still longer in use. In the former Duchy of *Modena* the metric system of weights and measures was introduced first in 1808, and reëstablished in 1849.

NETHERLANDS. — The French metric system of weights and measures was introduced by the law of 21st August, 1816, and the royal decrees of 29th March and 30th November, 1817. The length measure to be in force since 1821; square and field measure since 1821; fluid measure since 1830; commercial, medicinal, and apothecaries' weight since 1821.

The metric system established by the law of 1816 and decrees of 1817 applied the old designations to the metric units. The law of 7th April, 1869, established from the commencement of the year 1870 a new series of inter-

national names, with the optional use for the first *ten* years of the old denominations.

NORWAY. — In the Norwegian Parliament, on the 22d April, 1875, the government moved for the introduction of the metric system of weights and measures.[1]

PORTUGAL. — The French metric system of weights and measures compulsory since 1st October, 1868. Metric measures of length and surface have been legally in use in Lisbon since 1st January, 1860; in the provinces since 1st March, 1860; for capacity and weight throughout the whole land since the end of 1862. For customs, tonnage-dues, warehousing, and the assessment of taxes, the French system has been in force in Lisbon and Oporto since September, 1860; so, also, for the measurement of shipping by a decree of 25th August, 1860.

ROUMANIA. — (*Bucharest.*) — According to a royal edict of 27th November, 1874, the government is charged with the duty of introducing the new or French metric system of weights and measures, but its use is not yet accomplished. For railroad purposes they reckon according to the French kilometer.

[RUSSIA.[2] — An imperial commission was appointed in the winter of 1876–7, to visit Paris and to inquire and report upon the practical results of legislation on the metric system in France and other continental countries. This commission recommended the adoption of the same system in Russia. Metric weights and measures have been employed in the custom houses of the empire since 1870.]

SWEDEN. — The French system of weights and measures will be obligatory with the year 1883, permissive during the years 1881 and 1882; and for customs and postal purposes, also for railroad transportation, obligatory from the commencement of 1881.

The coin weight is in conformity with the Scandinavian coin convention of 18th December, 1872, — the French metric. The medicinal and apothecary weight is the French metric gram weight, in conformity with the law of 1864.

SPAIN. — (*Madrid.*) — French metric weights and measures, introduced by a law of 19th July, 1849, to go into operation in November, 1852. For a portion of the provinces the new system was in force on the 1st January, 1855, and in all Spain from 1st January, 1859.

SWITZERLAND. — By agreement or convention of 17th August, 1835, known as the "Maass concordats," entered into between twelve Swiss cantons, other cantons joining later, a modified form of the metric system was established, to go into operation generally with 1st January, 1840, an interval of four and

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[1] To this should be added mention of the recent official announcement (see p. 209) that the metric system is obligatory in Norway since Jan. 1, 1878. — *Editor.*

[2] This paragraph is interpolated to supply an omission — probably inadvertent — in the original document.

a half years, but in Lucerne in the year 1838, an interval of two and a half years.

The federal law of 23d December, 1851, introduced for the whole of Switzerland the system of "Maass concordat" of 17th August, 1835, to be in force in all the cantons at the latest by December 31, 1856, an interval of five years. The facts are that almost everywhere it has been enforced since 1st January, 1853, an interval of one year; in Neufchatel, however, since March 1, 1858, an interval of six years. In June, 1868, the federal council by law made the use of the *pure* metric system *optional* side by side with the present system of the "Maass concordats."

ASIA.

British East India. — (*Calcutta.*) — In the year 1859 the British East India Government recommended the introduction of the French metric system of weights and measures, but as yet without result.

An act to provide for the ultimate adoption of a uniform system of weights and measures of capacity throughout British India was passed by the governor-general of India in council in 1871. The act orders: —

Art. 2. — The primary standard of weight shall be called a *ser*, "a weight of metal equal when weighed in a vacuum to the weight known in France as the *kilogram*."

Art. 3. — The units of weights and measures of capacity shall be, for weights, the said *ser;* for measures of capacity, a measure containing one such *ser* of water at its maximum density, weighed in a vacuum.

Art. 4. . . . Every *weight* or *measure* of capacity other than said units "shall be an integral multiple or integral submultiple of one of the units aforesaid."

Unless otherwise ordered "the subdivisions of all such weights and measures of capacity shall be expressed in decimal parts."

The use of metric weights and measures is permissive, and the local governments are empowered to make it compulsory at discretion.

Turkey. — (*Constantinople.*) — The French metric system of weights and measures introduced by the organizing law of September, 1869, to go into effect for all purposes in the administration of the empire from March, 1871. Its use optional to the public from March, 1871, to March, 1874, from which date its use was to be obligatory.

The interval from the date of the organizing law to the use of the system for purposes of the government is one and a half years, and the interval from the date when made permissive to that when made generally obligatory is four and a half years.

Japan. — Weights and measures in general are non-metric, but for coinage, in part, the metric unit of weight is employed. "The gold *yen*, the unit of account, contains of fine gold one gram and a half and weighs one gram and two-thirds, being of nine-tenths fineness," consequently the dekagram of gold of the ordinary standard of nine-tenths fineness is equivalent in value ex-

actly to six *yens*. It is stated to be the intention of the government to introduce into Japan at an early period a new system of weights and measures based on the decimal system of France.

AFRICA.

EGYPT. — In July, 1875, the introduction of the metric system of weights and measures was ordered. For coinage, the gram-weight has already for some time been in use. For a measuremeut of shipping, the Turkish, the metric ton of 1,000 kilograms is used.

FRENCH COLONIES.

ALGIERS. — Since March 1, 1843, the metric system of weights and measures is legalized. The use of the older system is strongly forbidden, but it continues to a great extent in use.

REUNION, ISLE OF (*formerly Isle of Bourbon, and from* 1809 *to* 1814 *Isle of Bonaparte*), *Africa*. — Weights and measures, the old Parisian, but more and more the new metric coming into use. The metric weight, the half kilogram, has for many years been in general use.

SENEGAMBIA (*Africa*). — In the French Senegal colony, by a decree of 15th June, 1826, the use of the old weights and measures is forbidden, with the exception of capacity measures for fruit, and the French metric system introduced.

To us, then, the metric system is no longer an experiment. Already its use is obligatory in Belgium, France, Germany, Greece, Netherlands, Italy, Portugal, Roumania, Spain, and Switzerland; in the Argentine Republic, Brazil, Peru, San Domingo, United States of Colombia, and Uruguay — countries aggregating a population of 181,000,000 — while its use is partial or legalized in Austria, Azores, Madeira and Cape de Verde Islands, Central American States, Denmark, Japan, Sweden, Norway, Turkey, Spanish Possessions, Great Britain and the British Possessions, and our own country, aggregating a population of 375,000,000 more.

In view of these facts the obligatory use of the metric system in this country seems feasible, and, in my opinion, it is desirable. Not only will such use bring about a complete uniformity of standards throughout the country, but the system will prove especially valuable for international purposes.

J. K. UPTON.

LEGISLATION BY THE CONGRESS OF THE UNITED STATES, IN REGARD TO THE METRIC SYSTEM.

Following is the text of the act of Congress of July 28, 1866, legalizing the use of the metric weights and measures in business

transactions in the United States, with the table of equivalents established for practical purposes by the said act. This act and these tables are inserted here for convenience of reference: —

AN ACT to authorize the use of the metric system of weights and measures.

Be it enacted by the Senate and House of Representatives of the United States in Congress assembled, That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system, and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SECT. 2. *And be it further enacted*, That the tables in the schedule hereto annexed shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

Approved July 28, 1866.

Measures of length.

Metric denominations and values.		Equivalents in denominations in use.	
Myriameter	10,000 meters.	6.2317	miles.
Kilometer	1,000 meters.	0.62317	mile, or 3,280 feet 10 inches.
Hektometer	100 meters.	328	feet 1 inch.
Dekameter	10 meters.	393.7	inches.
Meter	1 meter.	39.37	inches.
Decimeter	1-10 of a meter.	3.937	inches.
Centimeter	1-100 of a meter.	0.3937	inch.
Millimeter	1-1000 of a meter.	0.0394	inch.

Measures of surface.

Metric denominations and values.		Equivalents in denominations in use.	
Hektar	10,000 square meters.	2.471	acres.
Ar	100 square meters.	119.6	square yards.
Centar	1 square meter.	1,550	square inches.

Measures of capacity.

Metric denominations and values.			Equivalents in denominations in use.	
Names.	No. of liters.	Cubic measure.	Dry measure.	Liquid, or wine measure.
Kiloliter or ster	1,000	1 cubic meter	1,308 cubic yards	264.17 gallons.
Hektoliter	100	1-10 of a cubic meter	2 bush. and 3.35 pecks	26.417 gallons.
Dekaliter	10	10 cubic decimeters	9.08 quarts	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quart	1.0567 quarts.
Deciliter	1-10	1-10 of a cubic decimeter	6.1022 cubic inches	0.845 gill.
Centiliter	1-100	10 cubic centimeters	0.6102 cubic inch	0.338 fluid ounces.
Milliliter	1-1000	1 cubic centimeter	0.061 cubic inch	0.27 fluid drams.

Weights.

Metric denominations and values.			Equivalents in denominations in use.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois weight.
Millier, or tonneau	1,000,000	1 cubic meter	2204.6 pounds.
Quintal	100,000	1 hektoliter	220.46 pounds.
Myriagram	10,000	10 liters	22.046 pounds.
Kilogram or kilo	1,000	1 liter	2.2046 pounds.
Hektogram	100	1 dekaliter	3.5274 ounces.
Dekagram	10	10 cubic centimeter	0.3527 ounce.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	1-10	1-10 of a cubic centimeter	1.5432 grains.
Centigram	1-100	10 cubic millimeters	0.1543 grain.
Milligram	1-1000	1 cubic millimeter	0.0154 grain.

The following is the text of the joint resolution of July 27, 1866, to enable the Secretary of the Treasury to furnish to each State one set of the standard weights and measures of the metric system.

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be and he is hereby authorized and directed to furnish to each State, to be delivered to the governor thereof, one set of the standard weights and measures of the metric system for the use of the States respectively.

Approved July 27, 1866.

LIST OF STANDARDS TO BE FURNISHED TO THE STATES UNDER THE FOREGOING RESOLUTION.

[This list, with the accompanying description and directions for use, was prepared by Prof. J. E. HILGARD, Assistant Superintendent of the U.S. Coast Survey, and Inspector of U.S. Standard Weights and Measures, for the information of the state authorities to whom the metric standards are delivered, and of such other persons as may be interested in the subject.]

1. *List of standards to be furnished to the States.*

Length:	One meter, end measure.
	One meter, line measure, divided.
Weight:	One kilogram.
	One demi-kilogram.
	One gram with subdivisions.
	One myriagram, or ten kilograms.
Capacity:	One liter.
	One dekaliter.

2. *Particulars of Meters.*

The end measure is of cast-steel, ten millimeters thick, thirty wide, with cylindrical ends, and small cylindrical projections in the axis, of hardened steel, with abutting faces, three millimeters in diameter, equal to one meter, legal standard of France, at the temperature of melting ice.

The divided line measure is of brass, composed of three parts of copper to one of zinc, the bar extending beyond the terminal lines; divided into decimeters, one decimeter into centimeters, and one centimeter into millimeters, the length between the terminal lines being equal to one meter at a temperature of the bar of about 68° Fahrenheit, or 20° centigrade, and each bar bears an inscription stating the temperature at which its length is equal to one meter. Each of these line measures is provided with a convenient tracing frame for copying the division.

3. *Particulars of Weights*

The kilogram is of brass, of an ascertained specific gravity; it is equal when weighed in a vacuum to the weight of the French platinum standard kilogram in vacuum.

Demi-kilogram, gram, and fractions to milligram.

Myriagram, or ten kilograms.

The form of the weights is similar to the present American standard weights, so as to be handled with hooks, forks, and pincers, which are provided.

4. *Particulars of Capacity Measures.*

The standard liter is of brass, composed of fifteen parts of the brass used for the meters, melted together with twelve parts of copper, and one part of tin; of a form similar to the American quart, containing a volume of distilled water, which, when weighed in vacuum, equals the weight of one French standard kilogram in vacuum, the water being at the temperature of its greatest density, and the vessel at the same temperature.

The dekaliter contains ten liters, as thus defined.

DESCRIPTION OF METRIC STANDARDS FOR THE STATES.

The three packing-boxes contain a set of standard metric weights and measures, carefully packed in walnut cases.

The packing-box marked "Weight" contains a myriagram, kilogram, demi-kilogram, gram, and the decimal fractions of a gram to include a milligram.

The box marked "Volume" contains a dekaliter and liter, with their ground-glass covers.

The box marked "Length" contains two walnut cases. In one of these is packed a steel meter, with hardened steel ends protected by brass caps; this is an end measure. The other walnut case contains a brass meter, which is divided into decimeters, centimeters, and millimeters, and is a line measure.

In the same case, and lying parallel with the brass meter, is a bar of wood of the same dimensions as the meter, held firmly in its place by means of wooden wedges.

This is so placed as to show the manner in which a bar of brass of the same dimensions can be secured for the purpose of having transferred upon it the meter and its decimal parts.

A tracer is packed in the box with the meter, and is operated in the following manner: —

After the brass bar, on which it is desired to have the meter and its parts transferred, is well secured in position by means of the wooden wedges, the tracer is placed upon the standard bar in such a position that the short line under the magnifying-glass shall accord with a line on the standard bar, and, while held firmly in this position, the movable portion of the tracer holding the cutter is passed carefully over the brass bar, making a mark upon it at right angles with its length. The tracer is then moved so as to accord with another line on the standard bar and another cut made on the brass bar. This operation is continued until a complete copy of the standard is transferred to the brass bar.

By the side of the cutter is a long steel screw, which can be set as a guide to determine the depth of the cut made by the cutter.

A revolving head on the tracer, with two notches filed in it, is placed there for the purpose of determining the length of the line cut. A steel screw in the movable portion of the Tracer is so placed as to strike against this head and stop the motion of the cutter in that direction, and it will be readily seen

that three different lengths of lines may be made by moving the head so that the stop-screw will at different times strike on the face of the revolving head and in the notches.

Before the brass bar is put in place it will be necessary to have it well prepared with a smooth surface, having lines traced on it in the direction of its length, similar to those on the standard.

The standard bar should never be moved from its place in the case.

The weights should never be touched with the naked hand. Lifters are placed in the cases.

THE METRIC SYSTEM IN THE MARINE-HOSPITAL SERVICE.

By an order of Surgeon-General John M. Woodworth, Supervising Director of the Marine-Hospital Service of the United States, approved by the Secretary of the Treasury, April 27, 1878, the use of the metric system is made compulsory in that service throughout the Union. This very important step of progress was taken after careful inquiry, and after the presentation of a very able and exhaustive report upon the subject by Oscar Oldberg, Doctor of Pharmacy, Chief Clerk and Acting Medical Purveyor of the Marine-Hospital Service, in which the disadvantages of the system in actual use and the desirability of reform are very forcibly set forth. The effect of this measure cannot but be to influence largely the practice of the medical profession, already very generally inclined, as appears by the action of many of its local or state organizations, in the same direction. The marine hospitals are dotted over the country, from Portland in the east, to New Orleans in the south, San Francisco in the extreme west, and St. Louis and Cincinnati in the interior. Thus the profession will have everywhere an example immediately at hand of the practicability and simplicity of the new system in actual use; and, in the little handbook prepared by the department, it will have a complete tariff of equivalent doses of all the drugs of the pharmacopœia in apothecaries' and metric weights and measures, which will remove all uncertainty in passing from one to the other.

The report of Dr. Oldberg deserves to be widely circulated and read, not merely for what it contains relating to medicine and pharmacy, but for its strong commonsense in treating the general question of metric weights and measures for the people. Two of the points made by the author are of special importance.

The first is, that, though the metric system provides numerous units which are multiples or sub-multiples of the basic units, yet in no single trade, profession, pursuit, or handicraft are more than about two of these units necessary. Thus, pharmacists will use only grams and centigrams; grocers, kilos and dekagrams; chemists, grams and milligrams; cloth merchants, meters and centimeters; physicists, centimeters and millimeters, and so on. Hence it follows that the objections, of which we hear so much, to the metric system, on account of its numerous denominations, — as if, for instance, the butcher and the baker were to be required to keep their books and state their bills in kilograms, grams, decigrams, centigrams, and milligrams, — are all entirely baseless and absurd, since they assume what is never going to happen.

The second point is, that, for all common purposes, it is entirely unnecessary to make any account of the decimal places in the equivalents of the metric units as expressed in the denominations of our ordinary measures. It suffices to take the nearest integer, or at least the nearest simple fraction. Thus, a meter, for all ordinary estimates, may be taken at $3\frac{1}{3}$, or $\frac{10}{3}$ feet; a gram, at 15 grains, etc. Even for more exact determinations of a practical character, not more than one or at most two decimal places need be retained. The higher decimals can never be of any consequence except for purposes of the severest scientific accuracy, — purposes which in no manner concern the ordinary life of man. This consideration reduces to very moderate proportions the alleged difficulty of supplanting the existing system by the metric, assumed to exist because of the incommensurability of the unit bases of the two.

Appended to the report of Dr. Oldberg is a complete and simple code of rules for transforming quantities expressed not only in Apothecaries' weights, but in Troy and Avoirdupois weights, and in the ordinary measures of length and capacity, into metric equivalents; and also tables showing the relations of the weights and measures of the two systems in such manner that the transformations from one to the other may be made without computation. The report, with these rules and tables annexed, forms one of the most valuable contributions to the literature of this subject which has yet appeared.

The following is the order of the Surgeon-General above referred to: —

TREASURY DEPARTMENT,
U.S. MARINE-HOSPITAL SERVICE,
Office of the Supervising Surgeon-General,
Washington, D.C., April 27, 1878.

Medical officers of the Marine-Hospital Service will hereafter, for all official medical and pharmacal purposes, make use of the Metric System of Weights and Measures. In expressing quantities by weight, the terms "gram" and "centigram" only will be used; and in expressing quantities by measure, the term "cubic centimeter." The Metric System has already, under the act of July 28, 1866, been adopted by this service for the purveying of medical supplies, and the weights and graduated measures, as well as the glass-ware, hereafter furnished the medical officers, will be in accordance therewith.

Simple rules for the ready conversion of terms of the United States Apothecaries' Weights and Measures into their respective equivalents in metric terms are appended, which, for all medical and pharmacal purposes, are believed to afford sufficiently accurate results. Suggestions are also given as to the mode in which metric medical prescriptions might be constructed, and in relation to the preparation of requisitions for medical supplies in metric terms.

JNO. M. WOODWORTH,
Surgeon-General U. S. M.-H. S.

Approved:

JOHN SHERMAN, *Secretary of the Treasury.*

METRIC WEIGHT IN THE POST-OFFICE.

The following is the act relating to metric weight in the post-office, referred to on p. 50 of the foregoing address. The statement there made, that there were two acts on the subject, one applicable to foreign, and the other to domestic postage rates, was derived from a member of the Committee on Weights and Measures, appointed in 1863 by the National Academy of Sciences, in compliance with a request of Mr. Chase, then Secretary of the Treasury, that the Academy should inquire, and report on that subject — which committee made report, in the month of January, 1866, and thus furnished the immediate occasion of the metric legislation of that year. The statement, nevertheless, was erroneous,

— the single act which follows, and which was intended to cover the whole ground, having been the only one passed. The intent of the framer of the act, however — which was to give to the citizen, on demand, the benefit of metric rates in the post-office, whether the metric balances should be immediately furnished or not — was defeated, owing to the inexplicitness of the language, which failed to declare the postal unit, in so many words, to be fifteen grams, but allowed the postmaster to say that, while for postal purposes a half ounce may be called fifteen grams, fifteen grams, on the other hand, shall not be accepted as half an ounce.

The law having been thus discovered to be practically inoperative, an attempt was made, in the revision of the statutes of 1873–4, to remove the imperfection; and the phraseology was changed so as to make it read, "fifteen grams shall be the equivalent for postal purposes of one-half ounce avoirdupois." Even in this form, however, the provision appears not to be considered by the post-office authorities as mandatory, and it continues to be disregarded.

AN ACT *to Authorize the Use in Post-Offices of Weights of the Denomination of Grams.*

Be it enacted, etc., etc., That the postmaster-general be, and he is hereby, authorized and directed to furnish to the post-offices exchanging mails with foreign countries, and to such other offices as he shall think expedient, postal balances denominated in grams of the metric system; and, until otherwise provided by law, one-half ounce avoirdupois shall be deemed, and taken for postal purposes, as the equivalent of fifteen grams of the metric weights, and so adopted in progression; and the rates of postage shall be applied accordingly.

Approved July 27, 1866.

REVISED STATUTES OF THE UNITED STATES.

TITLE XLVI. — THE POSTAL SERVICE. CHAPTER 3. — MAIL-MATTER.

SECTION 3880. The postmaster-general shall furnish to the post-offices exchanging mails with foreign countries, and to such other offices as he may deem expedient, postal balances denominated in grams of the metric system, fifteen grams of which shall be the equivalent, for postal purposes, of one-half ounce avoirdupois, and so on in progression.

Approved June 22, 1874.

State Legislation Favoring the Metric System.

Connecticut is believed to have been the first State in the Union that formally recommended the teaching of the Metric System in all the public schools. In the General Assembly of 1864 the following resolution, introduced in the Senate by the Hon. Wm. C. Fowler, was duly referred to the Joint Standing Committee on Education, afterward reported adversely by them; again discussed in the Senate and recommitted to the same committee, who, after a full hearing, recommended its adoption. After considerable discussion, the resolution was finally passed without opposition in either House.

Whereas, Nearly half the population of the Christian world use in part or exclusively the Metrical System of Weights and Measures; and *whereas*, it is in exclusive use in some departments of science, and in constantly increasing use in others; and *whereas*, the recent International Congress at Berlin, at which thirty-three nations of Europe and America were represented, have recommended that this system be taught in all public schools; and *whereas*, it is highly probable that the system will be adopted throughout the United States during the present generation;

Resolved by this Assembly, That the Superintendent of Common Schools and the various Boards of Education and of School Visitors in the several towns and School Districts of the State, be urgently recommended to provide that the Metrical System of Weights and Measures, together with its relations to the legalized systems, be taught in all the schools which are under their charge.[1]

The Massachusetts Legislature in 1876 passed the following: —

Resolved, That the senators and representatives in Congress from this Commonwealth are hereby requested to forward, by all legitimate means, the introduction of the metric system of weights and measures, as the sole legalized standard throughout the United States.

Resolved, That the governor be and he is hereby requested to transmit to each of the senators and representatives in Congress a copy of the foregoing resolve.

A year later the following act was passed. The first resolutions met with determined and protracted opposition. When this act was proposed it was supposed that its passage by the same legislature would be more violently opposed. To the surprise of its friends it was passed at once, being amended by the House so as

[1] See Senate Journal for 1864, page 261.

to give $1,200 instead of the $900 asked. Such evidence of the rapid growth of the system in public favor is most gratifying.

[CHAP. 40.]

AN ACT in relation to the Metric System of Weights and Measures.

Be it enacted, etc., as follows : —

SECTION 1. That from and after the passage of this act it shall be lawful throughout the Commonwealth of Massachusetts to employ the weights and measures of the metric system, and no contract or dealing or pleading in any court shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system. The metric weights and measures received from the United States, and now in the treasury of the Commonwealth, may be used and taken as authorized public standards of weights and measures; and these authorized standards shall in no case be removed from the treasury except under necessity for their preservation or repair.

SECT. 2. The following tables shall be recognized in the construction of contracts and in all legal proceedings as establishing in terms of the weights and measures now in use in the State of Massachusetts, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures, the weights and measures of the metric system. [Here follow the tables exactly as given on page 227. It is not thought necessary to reproduce them here.]

SECT. 3. The treasurer is hereby authorized and directed to procure duplicate sets of the metric weights and measures, conformable to the standards now in the treasury; of which two sets shall be retained for the use of the treasurer and his deputy, and from which there shall be furnished one set to the treasurer of each shire town and of each city not a shire town in the several counties of the Commonwealth.

SECT. 4. The duties of the treasurer of the Commonwealth and his deputy, and the duties and responsibilities of the treasurer of each town, with respect to the keeping, care, verification, and use of the standard weights and measures so furnished, shall be the same with those established by existing statutes with respect to the standard weights and measures heretofore provided. And it is hereby provided that no town in which there may be two or more sealers of weights and measures shall for that reason be required to procure additional sets of the metric weights and measures.

SECT. 5. The deputy of the treasurer shall verify, adjust, and seal all metric weights and measures that may be brought to him for that purpose, and he shall receive a reasonable compensation therefor. The sealer of weights and measures in each town that shall receive the standard metric weights and measures as hereinbefore provided, shall verify, adjust, and seal all metric

weights and measures that may be brought to him for that purpose from within the county in which such town is situated, and he shall receive a reasonable compensation therefor; but he shall claim no fees for any sealing, verification, or adjustment, for the performance of which he may otherwise receive compensation by salary paid by the town.

SECT. 6. All persons using weights or measures of the metric system for the purpose of selling any goods, wares, merchandise, or other commodities shall have them adjusted, sealed, and recorded by some authorized sealer of weights and measures and shall thereafter be responsible for the correctness and exactness of the same; and no person using illegally or fraudulently the metric weights or measures shall thereby be freed from any liabilities or penalties to which he would have been exposed in case the weights and measures employed had been the ordinary weights and measures heretofore and now in use in this Commonwealth.

SECT. 7. The expense incurred in carrying out the provisions of this act shall not exceed twelve hundred dollars; which sum is hereby appropriated.

SECT. 8. All acts or parts of acts inconsistent with the provisions of this act, are hereby repealed.

SECT. 9. This act shall take effect upon its passage. [*Approved March 20, 1877.*

Early in 1878 the New Jersey Legislature took the subject into consideration, and passed the following Act, under which the schools of the entire State are now being rapidly supplied with sets of metric apparatus.

Supplement to an act entitled "An act to establish a system of public instruction" (revision), approved March 27, 1874.

Whereas, The Metric Bureau of Boston, Mass., of which the Hon. Charles Francis Adams is president,[1] has offered to furnish metric weights and measures at a large reduction on the cost thereof, in order to encourage the general use of the same; therefore,

Be it enacted by the Senate and General Assembly of the State of New Jersey, That the State Superintendent of Education, with the approval of the State Board of Education, is authorized and directed to place in every public school of this State applying for the same, one simplest set of apparatus to teach the metric system of weights and measures.

And be it enacted, That the sum of two thousand dollars is hereby appropriated out of any money, not otherwise appropriated, in the State treasury for the purposes of this act.

And be it enacted, That this act shall take effect immediately.

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[1] In the haste of preparation, the name of the first vice-president was substituted for the president, F. A. P. Barnard, President of Columbia College, New York.

Section 3.—DIPLOMATIC NEGOTIATIONS AND INTERNATIONAL TREATY-CONVENTIONS FAVORING THE METRIC SYSTEM.

Under this head may be specially noticed two important compacts entered into within the last decade, between the leading nations of the civilized world. The first of these, conceived purely in the interest of metrology, as well theoretic as practical, and designed to secure the accuracy, uniformity, and permanent preservation of standards everywhere, is known as the convention to establish an "International Bureau of Weights and Measures." The other, designed to facilitate written correspondence between the inhabitants of different countries, and to provide for the unobstructed transportation of the mails of any one nation, a party to the alliance, across the territory of any other, is called a "Treaty Concerning the Formation of a General Postal Union." In what follows will be found a brief sketch of the history and the principal features of these two interesting international conventions. They are interesting in the respect that they are not, like most treaties, conceived in a narrow or selfish spirit, but have for their tendency, on the other hand, to promote the general good of the human race, to soften down the asperities between different peoples, and to show to what extent the interests of all nations are one.

"The International Bureau of Weights and Measures."

In the year 1867 there was assembled in Paris an International Convention to consider the subject of the unification of weights, measures, and moneys. This body, after mature deliberation, adopted a report drawn up by the eminent Prof. de Jacobi, of St. Petersburgh, setting forth the great superiority of the metric system of weights and measures over every other, giving an historical account of the progress which had been made towards its adoption by different nations, and concluding with a recommendation of the universal acceptance of this system as the metrological system of the world.

During the progress of its deliberations this convention appointed a committee to visit the Palace of the Archives in Paris, where are

deposited the prototype standards of the metric system, and to examine the condition of those standards, and report whether, in the interval of nearly three-quarters of a century since their construction, they had become in any way impaired. Of this committee the present writer was a member. The standards were found to be in a state which might, for the time being, be considered as satisfactory; but the extremities of the meter-bar showed, under the microscope, evidences of the frequent contact which they had suffered, and the form of the bar seemed not to be the best adapted to resist disturbances of its accuracy by accidental violence.

After the adjournment of the convention, some members of that body began to agitate for an inquiry into the propriety of constructing new prototypes, and, incidentally, of making a new verification of the truth of the old ones. This last idea was suggested by the criticisms which some eminent authorities have made of the length of the meter, and of the weight of the kilogram, as fixed by the international commission of 1799. Prof. de Jacobi, in 1869, visited England, and presented propositions of this nature to the British Association for the Advancement of Science. Early in the following year the European Geodesic Association addressed a memorial on the same subject to the Government of France. This Government was moved by the considerations thus laid before it to invite the governments of all the other nations with which France is in friendly diplomatic relations, to appoint delegates to an international conference to be charged with the duty of considering all the questions which had been raised in regard to the metric system, to settle all uncertainties in regard to its basic units, and to provide adequate securities for the perpetuation, unaltered forever, of its visible representatives; also to make authentic copies of the prototypes of the system, to be deposited with the several metric nations, and furnished to all others who should desire to possess them as standards of comparison and verification.

The invitation was very generally accepted, thirty states having sent delegates to the convention, which met for the first time in Paris, in the summer of 1870, just before the outbreak of the disastrous war between France and Germany. The delegates appointed on behalf of the United States were Prof. Joseph Henry, Secretary

of the Smithsonian Institution, and Prof. J. E. Hilgard, Assistant Superintendent of the Coast Survey at Washington. At the earliest meeting (at which Prof. Henry only appeared for the United States), though certain general principles were agreed on for the guidance of future proceedings, no great progress was made, effective deliberation having been prevented by the abrupt commencement of hostilities.

After the conclusion of peace with Germany, and the suppression of the communistic insurrection, a second meeting was called, which took place in 1872, when Prof. Hilgard appeared as the representative of the United States. This convention took into careful consideration the strictures which had been made upon the accuracy of the original standard meter and standard kilogram, but found in them nothing to justify want of confidence in the correctness of these standards.[1] The convention, therefore, resolved, that in the construction of new standards, the values of the original standard meter and kilogram should be strictly adhered to. The original standard meter had been what is called an end-meter, or meter *à bout;* but, while for some purposes a standard of such form is convenient, the accuracy of the end-meter is always in some danger of being impaired by the repeated contacts to which its extremities are subject, however delicately they may be made. Considerations of this kind induced the committee to resolve that the new meter should be a line-meter, or meter *à trait;* that is to say, a measure in which the standard length is the distance between two delicately-traced lines on the surface of the bar, which lines are to be observed microscopically, and never touched. They provided, however, that the end-meter should also be constructed, in order that facilities might always exist for comparisons and verifications by either method at pleasure. The metal which had been employed in the construction of the original meter bar and kilogram was pure platinum. This metal had been selected because of its incorrosibility and its difficult fusibility; it being impossible to melt platinum in any ordinary furnace. The objections to this material, however, are considerable, the principal one being its softness. In

[1] See note on the subject of the accuracy of the original prototype meter, at the end of this section.

preparing new standards, the convention resolved to employ an alloy of platinum and iridium, ten per cent. of iridium being united with ninety per cent. of pure platinum. This compound possesses all the merits of pure platinum, while it is free from the objections to that metal. Its expansibility is slight, its hardness and rigidity are very great; it is unalterable by acids, and infusible by any ordinary artificial heat; it can only be fused in a furnace specially constructed for the purpose, in which the material, supported on a bed of lime, is exposed to the direct action of many jets of the oxy-hydrogen blow-pipe.

The original standard meter had had the form of a simple flat bar; but this figure is not well adapted to resist flexure, and it was determined to give to the new standards a cross-section resembling somewhat the letter X, or the letter X and capital H combined; the lines denoting the limits of the standard to be traced on the bottom of the trough thus formed on one side of the cross-bar of the H. Inasmuch, also, as it was designed to furnish all the metric nations with carefully compared and verified standards, accompanied by their certified equations, and as it was desired that these standards should be, as nearly as possible, identical in character in every respect, it was farther resolved to construct the entire number from a single ingot, formed at one operation of melting. The difficult and responsible duty of preparing the bars in accordance with these rules was entrusted to a local commission composed of the delegates in the international convention representing France, all of them eminent members of the French Academy of Sciences. This commission were occupied with the preliminary portion of their task, which consisted in preparing the massive ingot from which the standards were to be made, for more than eighteen months, during which period their experiments, upon a comparatively small scale, of fusing together the metals chosen for the standard alloy, were very numerous. At length, on the 25th April, 1874, they produced, successfully, a mass of iridio-platinum of 80 kilograms in weight; on the 1st of May, a second one of 85 kilograms; and on the 7th May, a third of 90 kilograms.

Finally all these, having been first reduced to fragments and for the most part laminated, or rolled into ribbons, were fused into one; and on the 13th of May, after a process of only about an

hour and a half in duration, this portion of the labor of the commission was completed by the production of the great ingot of 250 kilograms, or more than 500 pounds. In the further progress of their work a portion of this mass was converted into metre bars of the prescribed form for presentation to the International Commission, and the rest left subject to the further order of the commission. Specimens of these bars were exhibited in the International Exposition of 1878, at Paris.

Before their adjournment, the International Commission appointed an Executive Committee of twelve members to receive the standard bars thus prepared and provide for their safe-keeping; and in other respects, within certain limitations, to act for the commission in the intervals of their sessions. In this committee our country was represented by Mr. Hilgard.

For the safe-keeping of the standards it was obviously necessary that there should be found or constructed some depository in which they could be preserved under conditions favorable to unalterability; where, for example, they should not be exposed to changes of temperature, or moisture, dust, or injury by accident. It seemed desirable also that the depository provided should be a convenient one in which to preserve and use the instruments and appliances which might be necessary for the comparison of standards, or for the construction of such new standards as might, from time to time, be required.

A further important question which presented itself to the commission was whether, in addition to a depository for the safe-keeping of these objects, there ought not to be appointed a custodian, with a staff of competent assistants, charged with the duty not only of keeping these instruments, but of using them for the purposes intended; and who should be always present to make comparisons, to carry on constructions, or to perform any other services appropriate to his office which the governments represented might assign to him. Such a personal organization was decided to be indispensable, and the commission accordingly reported to the government of France to that effect.

These recommendations having been favorably received by the French government, it was next in order to consider in what manner the expense involved in the creation of the proposed establish-

ment should be met. A diplomatic conference on this subject was therefore invited to be held between representatives of the powers whose delegates had participated in the proceedings of the commission. This invitation was in general promptly responded to; but in the United States the President, before acting, addressed, through the Secretary of State, to the National Academy of Sciences, a request for such information as to the relations of the proposed scheme to the interests of science and its importance to the material welfare of mankind, as might serve as the basis of his judgment in shaping his reply. This question was referred to a committee of the Academy, whose report was strongly favorable. As a consequence the President appointed Mr. Washburne, our minister at the time in Paris, to represent our country in the proposed diplomatic conference. The conference took place in March, 1875, and resulted in the conclusion of a convention in which it was stipulated that provision for the institution and maintenance of an International Bureau of Weights and Measures should be made by appropriations *pro rata*, from the different assenting nations; — the amount to be contributed by each to be determined by considering not population merely but also the question of the participation or otherwise of the contributing nation in the actual use of the metric system. The metric nations, meaning those with whom the system is obligatory, contribute in the proportion of three; those with which it is permissive, in the proportion of two; and those which have not adopted it at all, in the proportion of one; that is to say, the populations of the several states are to be multiplied by these factors respectively, and the distribution of expense to be made proportionately to the products.

The convention, as agreed on, was signed by the delegates, in some cases with full power, and in others subject to the approval of their governments at home. Mr. Washburne, before signing, referred the question by telegraph to the President, and received from him, in like manner, authority to affix his signature, and to bind the United States so far as the executive branch of the government could do so.

The ratification of the convention by the Senate was still, however, necessary. This, owing in part perhaps to the indifference of our public men toward most matters of which the immediate

and practical bearing is not distinctly perceptible, and in part to the absorption of the attention of both houses of Congress in the exciting political struggles which during the past few years have kept the country in a continual state of feverish agitation, was very slow in coming. During the lifetime of an entire Congress, the delay of the Senate to ratify was accounted for by Senators on the ground that the Committee of the House on Appropriations had reported no provision to fulfil the obligations imposed by the convention; and during the same period the House committee excused their neglect on the ground that the Senate had not ratified. At length, however, after a delay of three years, the ratification and the appropriation came together, and in April, 1878, the United States became in full a member of this International Alliance.

In the meantime the permanent committee of the International Commission had proceeded with the measures necessary for the establishment of the Bureau. An important preliminary question, what should be the geographical location of the Bureau, which had presented itself first of all, had been considered and disposed of. To some members of the commission it seemed desirable that the site should not be selected within the limits of territory of any of the great powers. On this account, and on account of its central situation, Switzerland was the preference of a number. The majority, however, favored France, both as a just tribute to the initiative which France had taken in the matter of metrology, and a recognition of the fact that the metric system had its birth there; and also because a location near Paris would place the Bureau in more immediate contact with artisans of the highest skill, whose assistance might from time to time be desirable. Moreover, the objection to the site arising out of the prominence of France as a leading power in Europe, was obviated by the guaranty offered by the French government, and supported by the governments of all the other contracting powers, that the neutrality of the site occupied should always be respected and maintained. In addition to this, the French Government offered an important inducement to the selection of a site near Paris, by proposing to concede to the Bureau the title to a very suitable tract of land in the Park of St. Cloud, upon a height overlooking the village and Porcelain Works of Sèvres, embracing about six acres, and having upon it already a large and

beautiful building, three stories high and fifteen meters by forty in plan, suitable for the offices and Council Chamber of the commission, and for the dwelling of the superintendent, known as the Pavilion de Breteuil. This pavilion has long been a favorite imperial and royal retreat. It is said to have been a frequent resort of the First Napoleon, when he retired for the purpose of study, and it dates back to the reign of Louis XV.; it overlooks all the surrounding country, and presents a very beautiful view of the city of Paris in the distance.

For the scientific and practical purposes of the Bureau, however, it was necessary to construct other buildings and to excavate a crypt out of the solid rock in the hill-side against which the land abuts; this latter being designed for the safe-keeping of the prototype standards themselves. The main building devoted to this purpose is of large dimensions — about forty meters long, by fifteen broad, but only one story in height — and embraces rooms for all the various operations of construction and comparison. Six of these apartments are intended for observations upon the expansibility of metal bars under varying temperatures, and are lined with double walls of corrugated zinc, between which steam or hot or cold air may be introduced, so as to provide artificial temperature without regard to the state of the external weather. The artificial cold is generated by means of the Pictet Freezing Apparatus, in which the desired depression of temperature is obtained by the evaporation of liquid sulphurous acid.

The direction of the Bureau is committed to an International Committee, consisting of fourteen members, in which no country is permitted to have more than a single representative. This is a permanent committee, holding office for six years, one-third of the number going out of office every two years, the retiring members being, however, indefinitely reëligible. The General Conference — constituted of all the representatives of all the powers by whom the International Committee are elected, and who have a limited administrative control — meet in Paris regularly every six years, and more frequently if occasion arises. The International Committee reports annually to the powers represented. The executive officers directly in charge of the Bureau consist of a director, an assistant director, an artisan who superintends the mechanical constructions,

and a janitor to guard the building and look after the service generally. At present these are the only paid officers, and their salaries and the expenses of repairs constitute all the charges, except those incidental to construction, which include the cost of material, the requisite tools, and other necessaries. The new buildings and their equipment have been already paid for, and have cost less than one hundred thousand dollars; while the site and the pavilion upon it, contributed by France, are estimated to be worth not less than two hundred and fifty thousand. The current annual expenses are not to exceed the limit of twenty thousand dollars.

Although this Bureau originated in a convention called especially to consider questions relating to the accuracy of the metric bases, and the propriety of constructing new prototypes of these bases, yet the larger design of its present organization looks beyond the advancement of this system exclusively, and embraces the more comprehensive object of promoting accuracy and permanence in all existing standards, and the maintenance between them, in fact and in practice, by means of frequent and strict comparison, of the exact relations which their theory requires. The Bureau will be, therefore, no less serviceable to non-metric than to metric nations. Considering the subject in this light, it is worthy to be noted that among the petitioners to the Congress of the United States, praying for the ratification, on our part, of the International Convention, which remained so long in doubt, were found the names of many who have publicly expressed their unwillingness to see the metric system of weights and measures made compulsory in this country. But these were men belonging to one or another of the scientific professions, whose daily experience impresses them continually, more and more, with the extreme importance of exactness in measurements of quantity, and therefore with the necessity of accurate standards of weight and measure, in order that such exactness may be secured. An earnest support was given to the object of the convention, therefore, not only by educationists and men of science, but also by practical men interested in the great workshops of the country, — the Locomotive and Machine Works of Philadelphia, the Hartford Arms Factory, the Waltham Watch Co., and many others.

It is one provision of the convention, that any of the signato- ory

powers may secede from it after the lapse of twelve years; but there is little reason to suppose that any of those who accede to it now will ever withdraw. The constructions at Breteuil are now substantially completed, and the Bureau is in operation. A little delay has occurred in the preparation of the standard meter bars from the large ingot cast by the French section of the original International Commission, which has arisen in consequence of the discovery that, by some accident, the alloy of the ingot is not strictly that which the commission intended, — that is to say, one-tenth part of iridium, and nine-tenths of platinum, — but that it contains a slight admixture of another of the rare metals associated with platinum, to wit, ruthenium. Since this ingot was cast, the methods of purification of these refractory metals have been considerably improved, and it is believed that no difficulty will be found at this time in obtaining precisely the alloy desired. Moreover, it is the belief of the French Commission that the impurity of the present alloy was not a consequence of any error in the process, but was the result of an introduction, by mistake, in preparing the materials for fusion, of a quantity of metal which had not been purified. The fact of the impurity was ascertained by means of an analysis instituted for security by the International Committee, before proceeding to construct the standards; and in consequence of the discovery some delay has occurred in the actual work of construction. At a meeting of the International Committee, held in the month of September, 1878, it was resolved, after considerable discussion, to accept a limited number of the bars prepared from this alloy, and, after having prepared others strictly in accordance with the original intent, to subject both to a severe comparison under great variations of temperature; the object of the trial being to ascertain to what extent, if any, the impurity affects the physical qualities of the compound, or is likely to endanger the usefulness, as standards, of the bars containing it. It is not anticipated that the irregularity of composition will be of any practical importance; but the theoretic objection presents itself, and is worthy of consideration, whether, when the amount of material at present on hand shall have been exhausted, it might not be difficult to produce precisely the same compound again. So soon as this question shall have been completely disposed of, the Bureau will

rapidly proceed to furnish standards to all the contracting nations, and to all others, whether nations, associations, or individuals, who may desire them. Its operations will be regarded with interest throughout the scientific world, and will unquestionably be very efficacious in promoting the spirit which is now everywhere seeking the universal unification of weights and measures.

The General Postal Union.

Until the year 1874 the regulation of postal intercourse between different peoples was a subject of special conventions, in which each government entered into stipulations with every other separately, and scarcely any two compacts were of the same character. With the rapid growth of commerce, the construction of vast networks of railroads upon land, and the introduction of steam as a motive power upon the ocean, which have been among the marked features of progress during the present century, postal intercommunication had immensely increased, and the inconvenience arising from irregularity in the service, delays, inequality of charges, and the absence of a common system, had become very serious. In this state of things diplomatic negotiations were set on foot among the leading powers, which resulted in the appointment of plenipotentiaries to meet in Congress, at Berne, in Switzerland, in the autumn of 1874, to take into consideration the evils here referred to, and to endeavor to devise some concerted plan for securing the regular, expeditious, and economical interchange of postal communications between nations.

The countries represented in this Congress were Great Britain, France, Germany, Switzerland, Belgium, Luxemburg, the Netherlands, Denmark, Norway, Sweden, Russia, Austria, Hungary, Roumania, Servia, Turkey, Egypt, Greece, Italy, Spain, Portugal, and the United States, — twenty-two in all. The total number of delegates was thirty-three; some of the states being represented by two delegates, some by three, but most of them by one only.

The result of the deliberations of the Congress was the conclusion of a convention, which, by subsequent ratification, became a binding treaty between the consenting powers, constituting of all the countries represented in the Congress a single postal territory,

subject to common regulations and moderate and substantially uniform rates. The treaty proper thus concluded consists of twenty articles; the detailed regulations annexed for carrying it into execution embrace thirty specifications additional.

Article first of the treaty is declaratory of a formation of a single postal territory, as above stated, under the title of "General Postal Union."

Article second defines the extent of the treaty in respect to the classes of objects admissible into the mails of the Union, which it defines to embrace letters, post-cards, books, newspapers, and other printed papers, patterns of merchandise, and legal and commercial documents originating in one of the countries of the Union and intended for another of those countries. It further declares the stipulations of the treaty to be applicable to the exchange by post of the objects above defined between countries of the Union and countries not belonging to the Union, in so far as the transportation of such objects takes place over the territory of two, at least, of the contracting parties.

Article third fixes the general Union rate of postage at twenty-five centimes (five cents) for the single prepaid letter, but reserves to each country the option to increase or diminish this rate according to its monetary or other exigencies; provided the rate levied do not exceed thirty-two centimes, or fall below twenty centimes. It also allows an additional charge for conveyance by sea of more than three hundred nautical miles within the limits of the Union, to the extent of not more than one-half the General Union rate for a paid letter. Prepayment of post-cards is compulsory, but not of letters. Upon unpaid letters, however, a double charge is imposed.

The *unit weight* for letter-postal purposes is *fifteen grams*. Every letter which does not exceed fifteen grams in weight is rated as single. Letters exceeding this weight pay a single rate for every fifteen grams or fractional part of fifteen grams.

Article fourth fixes the rates for mailable matter other than written correspondence. These, consisting of legal and commercial documents, patterns of merchandise, books bound or stitched, pamphlets, visiting cards, music, catalogues, prospectuses, announcements and notices of various kinds, whether printed, engraved, lithographed, or autographed, as well as for photo-

graphs, must pay seven centimes per packet; with the option reserved, as in the case of letters, to each country, to increase or diminish this rate within the limits of five centimes as a minimum and eleven centimes as a maximum.

The *unit weight* for this description of miscellaneous matter is *fifty grams*, which is the weight to be understood in the phrase "per packet." An additional charge for transportation by sea is allowed under the same conditions and at the same rate per cent as for letters. The maximum weight allowed is, for patterns of merchandise, two hundred and fifty grams; for all other miscellaneous matter, one kilogram.

Article fifth provides for the registration of letters, prescribes the charges for registration, and fixes rules for the case of loss of a registered letter, and the indemnification to be paid to the sender for such loss.

Article sixth requires prepayment when made to be made by means of postage-stamps valid within the country where they are affixed. It provides also for the disposition to be made of printed papers unpaid or insufficiently paid (they are not forwarded); and for the collection upon other matter insufficiently stamped, of the amount chargeable upon the same considered as unpaid (viz., double rates), less the amount of the stamps affixed.

Article seventh prescribes that no additional postage shall be charged for the re-transmission of postal articles within the interior of the Union; unless such article before being re-directed shall have passed through the interior service of only one of the countries of the Union, and after re-direction shall pass through that of another; in which case it shall be charged with the interior rate of this second country.

Article eighth exempts from postage charge all official correspondence relating to the postal service. Except this, no other franking is allowed.

Article ninth permits each office to keep the entire sum collected by it for postage, thus rendering unnecessary the keeping of accounts and settlement of balances between the offices. It also provides that no duties or taxes other than the postages prescribed by the treaty shall be exacted on matters sent by mail either in the country of origin or the country of reception.

Article tenth guarantees the right of transit through any and all the countries of the Union, for mails originating in any of these countries, whether the same be open or closed; and requires that closed mails as well as correspondence in open mails shall always be forwarded by the most rapid routes at the command of the post-offices concerned.

It provides further, that in compensation for the right of transit and the service rendered by the intermediate countries in forwarding such transmitted mails, the despatching office shall pay to the office of the intermediate territory the sum of two francs per kilogram for miscellaneous matter (net weight), whether the transit be in open or in closed mails. For letters a larger compensation may be exacted, but not more than four francs per kilogram. A similar increase may be exacted on miscellaneous matter when the transit provided is of more than seven hundred and fifty kilometers over the territory of one and the same national office.

For transit by sea to an extent exceeding three hundred nautical lines, the office furnishing the sea-service may claim of the dispatching-office a compensation not exceeding six francs fifty centimes per kilogram for letters, and fifty centimes per kilogram for miscellaneous postal matter.

Article eleventh treats of the relations of the countries of the Union with countries foreign to the Union, and provides that every despatching-office shall keep the whole of the Union rate for the prepaid correspondence addressed to foreign countries; and that every receiving-office shall keep the whole of the Union rate collected on unpaid correspondence originating in foreign countries.

Article twelfth relates to the exchange of letters of declared value and of post-office money-orders, which matters it leaves to be disposed of by ulterior negotiations.

Article thirteenth declares the post-offices of the several countries of the Union competent to prepare, by common consent, in the form of detailed regulations, all the measures of order necessary to the execution of this treaty.

Article fourteenth reserves to the parties of the Union the right to conclude any other treaties relating to postal matters not conflicting with this, with any other parties, whether belonging to or foreign to the Union, and to preserve unchanged whatever

postal legislation relates to the interior only of their respective countries.

Article fifteenth provides for the organization of a central office, under the name of "The International Office of the General Postal Union," to be conducted under the surveillance of a Postal Administration to be chosen by the Congress, and of which the expenses are to be borne by all the offices of the contracting states.

Article sixteenth provides for the decision by arbitration of any questions of difference which may arise out of the interpretation of the present treaty.

Article seventeenth sets forth the conditions on which admission to the Union may be obtained by countries beyond sea not yet forming part of it.

Article eighteenth requires that there shall be held, every three years at least, a Congress of plenipotentiaries of the countries participating in the treaty, with the view of perfecting the system of the Union, of introducing into it improvements found necessary, and of discussing common affairs. It appoints for the time and place of the next meeting, the year 1877, and the city of Paris, but provides that the period of the meeting may be advanced on the demand of at least one-third of the members of the Union.

Article nineteenth names the first day of July as the time at which the treaty shall take effect, and stipulates that it shall remain in force for three years from that date; after which it is to be considered as indefinitely prolonged, every party, however, retaining the right of withdrawal from the Union, on giving notice one year in advance.

Article twentieth abrogates all the stipulations of the special treaties previously concluded between the several countries so far as they may be at variance with the terms of the present treaty; provides for the ratification of this at the earliest possible date, and for the exchange of the ratifications at Berne.

The regulations of detail for the execution of the treaty, necessary to put it into practical operation, were drawn up and signed at the same time with the treaty itself, and by the same plenipotentiaries; these functionaries acting for this purpose as the rep-

resentatives of the post-offices of their respective countries. Among these numerous regulations there are few of sufficient interest to be cited here, as they relate mainly to the interior working of the several offices, and the relations of the offices to each other, rather than to the public. The following, however, are worth noting.

The twenty-fifth rule prohibits the admission into the international mails of any letter or other packet which may contain either gold or silver money, jewels or precious articles, or any article whatever liable to customs-duties.

The twenty-sixth rule prohibits the forwarding of post-cards not fully prepaid. The same rule, moreover, gives to each office the right not to forward, or to admit in its service, post-cards bearing any description of writing which may be forbidden by the statutory or administrative enactments in force in the country, and makes this rule applicable to letters or any articles otherwise mailable which shall bear externally any such writing.

The twenty-seventh rule selects the Administration of the Posts of the Swiss Confederation to organize the international office established by the fifteenth article of the treaty, and provides that that office shall commence its functions immediately after the exchange of ratifications. It limits the annual expenses of the office to seventy-five thousand francs, with the proviso that that sum may ultimately be increased with the consent of all the contracting offices. For the purpose of apportioning the expenses among the contracting parties, it distributes these latter into six classes, each of which is to contribute in the proportion of a certain number of units, viz. : —

The first	class	in	the	proportion	of	. . 25	units.
The second	"	"	"	"		. . 20	"
The third	"	"	"	"		. . 15	"
The fourth	"	"	"	"		. . 10	"
The fifth	"	"	"	"		. . 5	"
The sixth	"	"	"	"		. . 3	"

The countries included in the first class are Germany, Austro-Hungary, United States of America, France, Great Britain, Italy, Russia, Turkey.

The second class contains but one, viz., Spain.

The third embraces Belgium, Egypt, Netherlands, Roumania, Sweden.

The fourth includes Denmark, Norway, Portugal, Switzerland.

The fifth comprehends Greece and Servia.

The sixth has only one, viz., Luxemburg.

The International Office, among its other varied duties, receives from the several national offices, in the first half of each year, complete statistical details of the postal operations of the preceding year, prepared according to directions from the International Office, and incorporates those details into a general statistical report, which it distributes to all the national offices. The International Office is required to publish, by the aid of the documents which are put at its disposal, a special journal in the German, English, and French languages. The official language of the International Office is, nevertheless, to be the French, and the twenty-eighth rule requires that the letter bills, accounts, and other forms used by all the post-offices of the Union, shall be drawn up in the French language.

The twenty-ninth rule declares that the following dependencies of certain of the contracting powers shall be considered as belonging to the General Postal Union, viz. : —

Iceland and the Faroe Islands, as forming part of Denmark.

The Balearic Islands, the Canaries, the Spanish possessions in Northern Africa, and the Spanish postal stations on the western coast of Morocco, as forming part of Spain.

Algeria, as forming part of France.

Malta, as subordinate to the post-office of Great Britain.

Madeira and the Azores, as forming part of Portugal.

The Grand Duchy of Finland, as forming an integral part of the Empire of Russia.

This convention, which is eminently characteristic of the spirit which controls the advanced civilization of modern times, is destined to constitute one of the most powerful of instrumentalities for accomplishing the ultimate unification of the weights and measures of all mankind, and for making the metric system, for all purposes, — as it has already made it for some purposes, — the system of the world.

Note on the accuracy of the Prototype Meter (referred to on page 240.)

In various forms of publication concerning the metric system in recent years, much has been said mistakenly, and, for the most part, ignorantly, in criticism of the correctness of the original determination by the French geodesists, in 1799, of the length of the meter as one ten-millionth part of the Paris meridian. It is in the hope of throwing some light upon a matter which has been so greatly and so singularly misconceived, that it has been thought advisable to reproduce here the following letter, addressed, in December, 1878, to Dr. C. P. Culver, Clerk of the Committee on Coinage, Weights, and Measures of the House of Representatives of the United States Congress; in the latter portion of which this question is treated, and the true purport and value of the criticisms referred to are considered and estimated.

NEW YORK, December 9, 1878.

DEAR SIR: — I was absent from the country at the time your letter of last spring was received here; and on my return I supposed it would be too late for me to reply to you for any useful purpose. You requested me to make any suggestion or furnish any information which might occur to me in connection with the subject of the expediency of introducing into this country the metric system of weights and measures.

I do not know that I can contribute much to what I have already said, and what others have said, in print, on this subject; but since my return I have seen the printed replies of the officers of the Treasury Department and of the War Department to the questions of the committee, and I should like to say a word or two in regard to some of these.

Our friend, Mr. Hilgard, for instance, has a remark to the effect, that in estimating the extent to which the metric system has been already introduced, it is not at all to the purpose to count the republics of Central and South America, because the people of those countries are, in general, peasants and herders, who use no measures at all. This cannot be said in a spirit of hostility, for Mr. Hilgard is certainly not unfriendly to the proposed reform; but it involves a fallacy which, I am confient, he does not perceive. If the measure we propose were one the results of which we ourselves could expect personally to see, his objection would have more weight; but inasmuch as our legislation is not only for this, but for *future* generations, it is a very great thing to know that the peoples occupying portions of the planet which nature has marked as likely to be among the most populous and most productive, and probably hereafter most advanced in the arts of all the human race, are destined by legislation actually completed, to make use of that system of weights and measures which now prevails over nearly all the continent of Europe. The same remark may be made of India, where neither the metric system of weights and measures, nor any other, is generally prevalent; but where, on the other hand, the confusion is of a most perplexing character. The British Government and the Indian Government have seen that the

only true way out of this perplexity is to sanction the metric system, and to provide that it shall be in due and judicious time legally enforced. This being the case, it is of very little consequence to the real object we have in view (which is the future of the world in regard to metrology), that neither the South American States nor the East Indies now generally use the metric system, or any other system. The *certainty* that they are *going to use them*, is an argument of immense force in its relation to the real question before us.

There is another assumption on which I wish to comment for a moment, which I find, in two places at least, in these replies. One of these places is in the report of Mr. Upton, who is entirely friendly to the measure we propose, and the other is in the reply of General Meigs, who is intensely hostile to this measure. Both of these gentlemen say that the meter has been "ascertained not to be the ten-millionth part of the Paris meridian." General Meigs says, "It has been ascertained that the meter bears *no relation* to that quadrant." Mr. Upton says, "It has been *demonstrated* that the length of the quadrant of the meridian was not accurately ascertained." I am astonished at the positiveness of these assertions. Nothing of the kind has been either demonstrated or ascertained. On the other hand, I think that the evidence is altogether in favor of the accuracy of the determination made by the great French geodetic commission. I do not, indeed, think it possible, in the present state of science, to determine with *positive* exactness the length of any quadrant of any meridian; but I do think it possible to determine that length within a limit, which shall leave room for no *sensible* error; and that I believe was done in the case of the French meridian. What *has* been "ascertained" is that the earth is not regular in its figure. The speculations of Mr. Bessel, Professor Airey, and General de Schubert were founded upon an hypothesis which they pleased to assume to be true for the purposes of their calculations. They assumed that the earth, though not a sphere nor a flattened spheroid, was, nevertheless, a regular geometrical ellipsoid of three axes. If anything has been proved by the surveys, it is that their hypothesis is a mere fancy. It follows that the most probable result to be obtained in endeavoring to determine the length of a meridian must be derived *from actual measurement on the meridian itself.* The mathematicians I have mentioned made inferences as to the Paris meridian by arguing from measurements on other meridians, as in Russia, India, and South America, on the supposition that the earth has a regular geometrical figure.

Assuming as a basis such an hypothesis, that is to say, an supposition of the truth of which we have no sufficient evidence, and which in all probability is not true, there is no sort of anomalous result which cannot be worked out when you attempt to combine the measurements of different meridian arcs with each other for the purpose of inferring the earth's figure, on the supposition that such figure is geometrical. Colonel Everest, the accomplished director of the Indian survey, by similar combinations obtained about seventy-seven different results, all giving different equatorial and different polar diameters.

This fact alone shows the absurdity of trying to deduce the length of the quadrant of the Paris meridian by mathematical deductions from the measurement of meridians elsewhere. In the present state of science, as I have said before, the securest way of finding a result approximating the length of any given meridian is to make the measurement on that meridian itself; and that is what the French commission did. I suppose an abler commission was never employed in similar work anywhere.

The publication in this country, and wide circulation (through a shrewd scheme of the late Professor Davies to scatter his crude views at the expense of the State of New York) of Sir John Herschel's lecture on the meter, the yard, and the pendulum, has given to the speculations of Airey and de Schubert a notoriety among us which Colonel Everest's no less able and far more comprehensive computations have not attained. This lecture, though bearing the mark of Herschel's great ability, is, nevertheless, in my view, very little creditable to his judgment, and deserves by no means the amount of consideration which some have been disposed to give it. But the thing which astonishes me most in this matter is that men of education, and men highly esteemed as men of science, should, at this day, so little understand this question as to say that there has been anything "demonstrated" to invalidate the accuracy of the established base of the metric system. I hope, therefore, the report of your committee, whatever may be the conclusions of the committee in regard to legislation recommended or discouraged, will not lend its sanction to a statement so entirely unfounded as that which I have referred to as disfiguring the otherwise able replies to the committee from the Chief Clerk of the Treasury Department, and from the office of the Quartermaster-General.

I am, very truly yours,

F. A. P. BARNARD.

DR. C. P. CULVER,
Clerk of the Committee of the House of Representatives on Weights, Measures, and Coinage.

Section 4. INDIVIDUAL AND ORGANIZED EFFORT IN BEHALF OF METROLOGICAL REFORM.

Individual Effort. — Much of the growing favor with which the metric system is regarded in this country is due to the earnest and persevering efforts of individual friends of the proposed reform, in diffusing information in regard to it among the people, and awakening a general interest in it throughout the community. It would be difficult here to do justice to the labors of all those who have in this way contributed to the advancement of the common cause, and it might seem invidious to discriminate among them by mentioning a few, to the exclusion of the rest; but there are some whose relations to the movement have been so peculiar, or whose activity has been so great and whose success so signal, that they may be named without the danger of incurring such an imputation.

In enumerating these, the first place must justly be assigned to the Hon. Samuel B. Ruggles, of New York, as having been earliest among the men of leading position, ability, and influence in this country to enter the field in advocacy of a thorough reform of our imperfect system of weights and measures. Mr. Ruggles is characterized, not only by a singular zeal of his own in the prosecution of any object to which he directs his attention, but also by a remarkable power of inspiring zeal in others; and it was chiefly owing to his untiring activity and his energetic efforts that the numerous petitions from Boards of Trade, Chambers of Commerce, scientific associations, institutions of learning, and other corporate bodies, in favor of the metric system, referred to in the report of Mr. Kasson, mentioned below, were laid before the Thirty-ninth Congress. It was at his personal instance that the memorial of the Trustees and Faculty of Columbia College, mentioned in the opening of the foregoing address, which was, perhaps, the first of all the papers of this class to be prepared, was presented to the Thirty-eighth Congress in 1864. When, in 1863, a committee of the National Academy of Sciences was appointed at the request of the Secretary of the Treasury, to consider the subject of metrological reform, Mr. Ruggles, as a citizen of eminence thoroughly conversant with the subject, and deeply interested in the object pro-

posed, was added to the committee, under a provision of the constitution then existing, designed to secure to the academy the advice and coöperation of eminent experts not of their own number, in the investigation of this class of questions of practical importance; and his counsel was not without its influence in determining the early and favorable action of that body.

At the August meeting of the Academy, in 1866, held at Northampton, Mass., Mr. Ruggles was present, having in his possession specimens of the metric five-cent copper-nickel coins authorized by the Act of Congress of May in that year, and which had been prepared for examination and approval in advance of the issue for circulation; and it was with an air of triumph approaching exultation that he held up these specimens before the Academy as the first legal recognition in visible and tangible form of the metric system of weights and measures in the United States. In concluding the brief remarks with which he accompanied the announcement, he threw one of the coins on the table with these words, "There, gentlemen, is your money. It is coined at your request. It will serve you at pleasure a double purpose — to weigh your letter or to pay your postage."

Mr. Ruggles has honorably represented the United States in the International Statistical Congresses, held at Berlin in 1863, and at the Hague in 1869, and also as Commissioner at the International Exposition at Paris, in 1867, and as delegate at the International Monetary Conference which met during the same year, also in the French capital. During all this long period he has labored indefatigably, not only to promote the unification of the metrological systems of the world, but also to advance the no less important, and practically even more difficult, object of bringing into simple relations, if not reducing to substantial identity, the diverse and incongruous systems of money and coinage by which the commercial exchanges of the world are so seriously embarrassed. To this latter subject he has given his more especially earnest attention in recent years. Though as yet the difficult problem remains unsolved, his persistent efforts have done much to impress upon the mind of the age a sense of the extreme importance, if not of the urgent necessity, of its early solution.

It is proper here to note the fact that the adoption in committee,

and the enactment by Congress, of the provision of the coinage act of 1873, by which the weights of the subsidiary silver coins of the United States were made metric, was secured mainly through the influence of Mr. Ruggles.

To Prof. Hubert A. Newton, of Yale College, an active member of the committee above referred to, is largely if not chiefly due the immediate credit of securing the legislation of 1866, making the metric system permissive in the United States, and establishing metric rates for our postal service, the benefits of which our people have not yet been permitted to enjoy. He spent some time in Washington in promoting these measures, at a period when so little information or interest in regard to the subject existed in the country that he was compelled to labor almost alone. The two bills of 1866 relating to these matters were drawn up by him, and after their passage he procured the publication in pamphlet form, for general distribution, of an extensive series of tables for converting quantities expressed in metric units into their equivalents in our common system, and the reverse, which he had prepared for the purpose of making the system extensively known, and which were simultaneously published in the annual report of the Smithsonian Institution.

Without active support in Congress, however, the measures urged by Prof. Newton could have had no prospect of success. Fortunately, they found in the Hon. John A. Kasson, member of the Lower House from Iowa, now Minister Plenipotentiary of the United States at Vienna, a very efficient champion, whose able advocacy secured the attention of the Houses, removed the obstacles which might have obstructed their passage, and carried them in the end triumphantly through. To his efforts in Congress on behalf of this desirable reform, Mr. Kasson subsequently added others, by addressing his fellow-citizens on the subject, from time to time, in his private capacity, and by encouraging organized effort to promote the same end. In the formation of the American Metrological Society he took an active part, and was elected its first vice-president. He is also one of the Executive board of the American Metric Bureau.

Early in the year 1874, Mr. J. Pickering Putnam, a rising architect of Boston, made a zealous effort to engage his professional

brethren throughout the country in a league, by which they should bind themselves to employ in their professional business, from and after the first day of July, 1876, the metric measures only. In pursuance of this object, Mr. Putnam sought first to secure the manifestation of an influential public opinion in favor of the contemplated measure, by interesting in it men of the highest standing in the community, including, as far as possible, the recognized leaders of public sentiment. A printed circular, issued by him in 1875, presents the names of nearly two hundred gentlemen, all occupying conspicuous positions before the public, as statesmen, jurists, authors, editors, presidents and professors of colleges, civil engineers and others, who testify to their approbation of his scheme, and recommend its adoption. The appeal was largely successful, and very many architects of our principal cities gave their assent to the proposed compact. Since the organization of the Metric Bureau, Mr. Putnam has been an officer of that body, and one of its most active members. He is the author of Putnam's Metric System, the most widely circulated book on the subject, and also of the series of charts which have been scattered very widely through the country by the society. He has written numerous articles for periodicals, and, with other officers of the Bureau, has given frequent popular addresses on the advantages of the metric system.

Prominent among the number of those whose zealous labors and persistent activity have been most conspicuous and effectual in promoting the progress of metric reform in this country, should be mentioned Mr. Melvil Dewey, now of Boston, who, in the capacity of Secretary, has principally managed the affairs of the Metric Bureau since its establishment, and who has done more than any other to scatter far and wide useful information on this subject throughout the country. Mr. Dewey deserves particular credit for the fact that he has given himself almost wholly up to the work of this reform, and thus has kept vigorously alive the activity of one of the most effective instrumentalities ever created in this or any other country for the promotion of an object of great public interest. He has had entire charge of the general offices of the Bureau, and with his assistants, Mr. H. E. Davidson and Miss E. M. Hadley, has received several thou-

sands of visitors interested in learning more of the metric system. To the very great correspondence of the Bureau he has from the first given his personal attention, and has constantly written, almost always anonymously, articles short and long for periodicals and books, setting forth the advantages and urging the adoption of the international measures.

To Dr. Edw. Wigglesworth, Lecturer in the Harvard Medical School, and one of the most prominent of the younger physicians of New England, the Metric Bureau has been indebted for coöperation so zealous and effective, and for pecuniary support so freely given, that his name cannot be omitted from even the shortest roll of honor. In every time of special need of funds to carry on the work, his purse has been opened, so that his gifts largely exceed those of any other individual. Not only of money, but of time, and the best ability has he given freely. A large number of addresses before national, State, and local medical associations and other bodies; many telling articles and arguments for the press; and several of the best circulars and tables yet printed for the convenience of physicians and druggists, are among the results of his constant labor; while at his expense, and through his efforts, many thousands of circulars have been placed in the hands of those specially interested.

Among the gentlemen who have most earnestly spoken and written in behalf of this cause, and who by their official position have been enabled to labor with the greatest effect, Mr. J. D. Philbrick, Superintendent of the Public Schools of Boston, and Mr. B. G. Northrop, Secretary of the Connecticut Board of Education, deserve especial notice. It is largely through the influence of these gentlemen that the metric system has been carried into the public schools of these two leading States, and that provision has been made, or efforts have been set on foot, for providing that the teaching shall be accompanied and made practical by the presence in the schools of the weights and measures themselves. Mr. Philbrick, in a concise but lucid paper [1] published in March, 1877, set forth the argument in favor of the system, described to teachers the apparatus which would be necessary to illustrate it in schools,

[1] The Bureau republished this pamphlet and furnishes single copies post free to applicants.

and pointed out where such apparatus could be obtained at an insignificant cost. Mr. Northrop, in the same year, in a report on the "Lessons" to be learned "from European Schools and the American Centennial,"[1] went more fully into the history of the subject, and made an earnest appeal to teachers to assist "in preparing the public mind for the general appreciation and use of metric measures through our schools." Mr. Northrop's essay gives some striking illustrations of the relative facility of effecting computations by the two systems, the present and the metric; and furnishes some encouraging statements of the progress already made in the practical introduction of the metric weights and measures into this country by the voluntary adoption of them in business transactions by manufacturers and others.

Prof. Persifor Frazer, of Philadelphia, has rendered a very important service to the progress of enlightenment on this subject by the publication of a very able essay demonstrating the superiority of the metric system, exhibiting in comparative tables the immense advantages it affords to computations over every other, and examining, and very effectually disposing of, the various objections which have been urged against its introduction into this country. Prof. Frazer is also the author of an admirably compact series of tables of metric equivalents, in which everything of importance is compressed into a shape which allows it to be carried in the vest-pocket.

Mr. J. W. Nystrom, of the same city, has also lent a very valuable aid to the cause of metrological reform by the publication of a powerful argument in refutation of the objections to the metric system — a system which, in comparison with that at present in use, he esteems and proves to be infinitely preferable — although he is the advocate of such a transformation of our system of arithmetical numeration and notation as would destroy the harmony between it and the metric ratios on which the superiority of the metric system principally depends. Mr. Nystrom would substitute *twelve* for *ten* as the base of our arithmetical numeration; the advantage being that the new base would be divisible by the factors 2, 3, 4, and 6, while the present base is divisible only by 2 and 5. It

[1] Published in N.Y., at 50c. The Bureau sends it, and all other metric publications, for half price.

needs no very elaborate argument to show that our arithmetic would have been in many respects a more convenient instrument in computations, and would, perhaps, have allied itself more advantageously with the practical affairs of life, had it been originally constructed upon a duodenary scale. This is a view which has been heretofore presented by every writer upon the general theory of arithmetic. No one, however, has been sanguine enough to believe that, in this stage of the world's history, the transformation could be effected. Considered as a practical scheme, Mr. Nystrom himself would probably despair of seeing it accomplished. Concurring with him, therefore, fully in his exalted appreciation of the ideal beauty of this abstract conception, which must always continue to be an abstraction, we are entitled, nevertheless, to count the whole weight of his authority, so far as there is any practical question to be affected by it, as entirely on the side of the metric system.

Another name which ought not to be omitted in speaking of the individuals whose intelligent zeal in this cause and whose able advocacy of the principles of the metric reform have contributed most largely to diffuse information on the subject among the people, and to enlist educational influences in its behalf, is that of Dr. J. B. Thomson, of New York, the author of numerous highly approved text-books extensively in use in the schools of our country. Dr. Thomson has introduced into his several school arithmetics one of the clearest expositions of the metric system to be found in any of the elementary works designed for the use of learners in this country; which is destined to contribute in an important degree in preparing the rising generation to welcome the inevitable change certain to come in their time, if not earlier, and to enable them to reap, without the embarrassments which the present generation encounters in struggling with the subject, the full benefit it will bring.

Prof. Thomson, moreover, deserves especial credit for the energetic and persistent manner in which he labored before the University Convocation of the State of New York to combat the reactionary views of the majority of the committee on weights and measures, of which he was a member; and for the convincing argument of his minority report presented to the Convocation in 1872. This was not the first time in which he had borne his pub-

lic testimony in favor of the metric reform. He has been from the beginning one of its warmest advocates. The report referred to, since revised and published in a separate form, is one of the most satisfactory expositions of the various interesting questions involved, to be anywhere found in the same compass.[1]

ORGANIZED EFFORT. — *The American Metrological Society.* — Of the organizations which have been formed with the exclusive object of promoting metrological reform in the United States, the first in the field was the American Metrological Society, — an organization which originated in a call addressed to the friends of the movement, of which the following is a copy: —

COLUMBIA COLLEGE, New York, October 22, 1873.

SIR: — The diversity of the conventional methods employed by different peoples for determining the quantities and values of material things has been in all times a source of infinite embarrassment to the operations of commerce, and a serious obstacle in the way of intelligent intercommunication between nations. The present century has been witness to the growth of a very earnest feeling, manifesting itself more or less decidedly in every civilized country, in favor of some such modification of existing metrological systems as to bring them all into simple relations with each other, if not to merge them into one. This feeling has already been productive of very substantial results. Much real progress has been made towards the assimilation of the unit-bases of systems of weight and measure, especially on the continent of Europe. The English-speaking nations have as yet, however, taken no active part towards promoting this important reform, notwithstanding that both in Great Britain and in our own country there are multitudes who are deeply impressed with a conviction of its desirability, and even of its necessity.

In the interchange of thought which has taken place during the last two or three years between gentlemen in different parts of the United States interested in this subject, a desire has been frequently expressed for the formation of an association to take into consideration the various interesting questions connected with metrological reform, to spread information in regard to these

[1] This report is published by Clark & Maynard, N.Y., at 25 cents per copy. The Metric Bureau, to secure it the widest possible circulation, have arranged to furnish it, and offer it, with several other metric books, at half price. The offer includes Putnam's Metric System, with illustrations and folded chart, full price $1; the Metric Charts, price .15, .20, .30, 1.50, 2.00, and 3.00; Northrop's Lessons, .50; Frazer's Metric System, .20; Frazer's Pocket Table, .03; and many other metric publications of real merit which the authors or publishers are willing to assist the society to distribute by furnishing at half regular rates.

among the people, and to concentrate effort towards the accomplishment of such practical measures of improvement as upon full deliberation it may seem judicious to attempt. This feeling has at length embodied itself in the following communication addressed to the undersigned, requesting him to take the initiative towards the formation of such an association by calling a meeting for that purpose: —

"*To* PRESIDENT F. A. P. BARNARD, *Columbia College, New York:* —

"SIR, — The undersigned, deeming it desirable that something should be attempted, by means of united and associated effort, to simplify the existing numerical relations between the units of measure employed by different nations, request you to lend your aid towards forming an organization for that purpose, by calling an early meeting of persons interested in the object indicated.

"Yours very respectfully,

"JOSEPH HENRY,	JOHN D. RUNKLE,
ARNOLD GUYOT,	WILLIAM WATSON,
E. B. ELLIOTT,	THOS. R. PYNCHON,
J. E. HILGARD,	M. C. MEIGS,
H. A. NEWTON,	B. F. CRAIG,
W. P. TROWBRIDGE,	C. S. LYMAN,
JOSEPH LOVERING,	JAMES D. DANA,
THOMAS HILL,	SAMUEL D. TILLMAN,
JOSIAH P. COOKE, JR.,	STEPHEN ALEXANDER."

In compliance with this request, therefore, the undersigned respectfully invites your attendance at a meeting to be held at Columbia College, on Tuesday, the 30th day of December next, at 2 o'clock, P.M., for the purpose of forming a preliminary organization, with a view to systematic and persistent action in favor of metrological reform, and of consulting as to the principles which should govern the proposed association, and the practical objects towards which its labors should be directed.

Very respectfully, etc.,

F. A. P. BARNARD.

The meeting thus invited took place at the time and place named, and proved to be an encouraging success. The gentlemen who attended, and who subsequently became members of the Association, were not all of them devotees of the metric system; some were even opposed to it; but they were all earnestly in favor of some reform of the exceedingly ill-adjusted, inconvenient, and illogical system of weights and measures in actual use in our

country. At this first meeting a constitution was drawn up, in Article II. in which the objects of the Society were set forth as follows: —

ARTICLE II.

OBJECTS OF THE SOCIETY.

SECTION 1. — The primary object of this Association shall be to improve the systems of weights, measures, and moneys at present existing among men, and to bring the same, as far as practicable, into relations of simple commensurability with each other.

SECT. 2. — A further object will be to secure the universal adoption of common units of measure for the expression of quantities which require to be stated in presenting the results of physical observation or investigation, and for which the ordinary systems of metrology do not provide; such as the divisions of the barometer, thermometer, and densimeter; the amount of work done by machines; the amount of mechanical energy, active or potential, of bodies, as dependent on their motion or position; the quantities of heat present in bodies at given temperatures, or generated by combustion or otherwise; the quantity and intensity of electro-dynamic currents; the aggregate and the efficient power of prime movers; the accelerative force of gravity; the pressure of steam and of the atmosphere; and other matters analogous to these. The Association will endeavor, also, to secure uniformity of usage in regard to standard *points of reference*, or to those physical conditions to which observations must be reduced for purposes of comparison; especially the temperature and pressure to which are referred the specific gravities of bodies, and the zero of longitude on the earth.

SECT. 3. — In regard to the denominations of weight, measure, and money which are derived from the unit-bases, the Association will labor to secure, as far as may be, the acceptance of the system of decimal derivation; not necessarily to the exclusion for practical purposes of the binary or other convenient methods of division; but maintained along with such other methods, on account of the facilities for calculation, for reductions, and for comparison of values, afforded by a system which conforms to that of our numerical notation.

It will be seen that the Society embraces within its scope a variety of questions relating to the measurement of quantities, which do not concern commercial transactions or the ordinary business affairs of every-day life. And in the prosecution of this more enlarged design it has, through committees from time to time appointed, instituted inquiries into various matters of scientific or general interest not connected with weights and measures in the

usual sense of those words; such as the definition of units of force and energy to be employed in physical investigations; the division of the day and of the year, and the proper standard of time; coinage, national and international, and the unification of monetary systems, etc., etc. The Society has also sought to collect information as to the variety of measures in actual use in different parts of our country under the same names, with a view to illustrate to what an extent the existing system is objectionable for its uncertainty as well as for its irregularity; it has endeavored to promote uniformity in certain practical matters, such as the adoption of a standard gauge in mechanical engineering, the use of identical methods by railroad engineers in making surveys of levels, and in testing the accuracy of their instruments, and in providing for the preservation of the resulting profiles for scientific purposes; and it is a part of its present aim, not yet accomplished, to secure the introduction and public display of the several standards of metric measure in state capitols, and other public buildings, for the purpose of making these measures familiar to the people.

The Society has, from year to year, ever since its formation, very earnestly memorialized Congress in favor of the introduction of the metric weights and measures into the public service, and especially into the Custom House, the Mint, the great public surveys, and the Post Office. In May, 1875, on the receipt of intelligence that a convention had been entered into at Paris by representatives of the leading powers of the civilized world, to which the executive government of the United States had also given its assent, for the creation of a permanent international Bureau for the construction, comparison, and verification of standards, and to serve as a tribunal of last resort in all matters relating to the metrology of the world, the Society placed on its minutes the following resolutions, expressive of their gratification at the consummation of this important measure of progress: —

Resolved, That this Society has received with gratification the intelligence of the ratification of a convention between the leading powers of the civilized world, establishing an international Bureau of weights and measures, for the purpose of perpetuating forever, without change, the basic units of the metric system of weights and measures, and the distribution of authenticated copies of the prototype standards of that system, as well as for the exact comparison

of standards of all descriptions and the determination of their relations to those of the metric system.

Resolved, That the action of our own executive government in accrediting a representative of the United States to the diplomatic conference in which this convention was entered into, and in authorizing its representative to sign the convention on the part of the United States, is especially gratifying as evincing the sympathy of the enlightened statesmen at the head of our government with all measures which tend, like the simplification of metrological systems, to facilitate international intercourse, and thus to promote peace and harmony between different peoples.

When, subsequently, it appeared to be doubtful whether the convention thus entered into by the executive authorities of the United States would receive the ratification of the Senate, or whether Congress would make the appropriations necessary to meet the obligations devolving upon our country under it, the Society added its voice and influence to those of other scientific and professional associations, in earnestly praying for early and favorable action in this important matter from our national legislature. Whether the desired result which it was the object of these efforts to secure was accomplished in consequence of them, cannot, of course, be certainly known; but it was accomplished nevertheless, though only after a delay of three years — the ratification of the convention by the Senate having taken place in May, 1878.

On the subject of a standard of value in coinage, also, the Society, in 1876, adopted certain very emphatically expressed resolutions, which, in view of the recent agitation of this subject in our public journals and public councils, are worthy of being reproduced here. These resolutions are in the following words: —

Resolved, That the recent large depreciation in the value of silver brings prominently to view the disadvantage of a double standard of coinage, and especially the danger to public and private credit, which, without a readjustment of the relations between the standard metals, must attend the return to such double standard after it has been practically abandoned.

Resolved, That in the view of this Society any legislation which proposes to make silver coin a legal tender to indefinite amounts, would be disastrous in its consequences to the business interests of the country, and is greatly to be deprecated.

Resolved, That no further legislation in regard to the relations of gold and silver ought to be attempted until there shall have been an interchange of

views between the leading powers of the civilized world, all of whom are deeply interested in this important question, for the purpose of agreeing, if possible, upon the adoption of a common policy concerning it.

Resolved, That an International Conference, called for the purpose of such comparison of views, might properly be charged, not only with the duty of considering what should be the relations maintained between the metals used in coinage, and what should be the functions they should severally fill in the monetary system, but also with the further duty of inquiring into the possibility of establishing a common unit for the moneys of account and coinage of all nations.

Resolved, That the recommendation recently addressed by the Chamber of Commerce of the City of New York to the Congress of the United States, to the effect that an invitation be extended to the governments of foreign nations to appoint delegates to be assembled at our national capital during this centennial year, to deliberate on the important matters above referred to, and to devise means for securing, if possible, the harmonious action of all the powers in regard to monetary affairs, is one in which this Society heartily concurs, as being likely, if adopted, to be productive of substantial benefit to the whole civilized world.

Resolved, That copies of these resolutions, authenticated by the signatures of the President and Secretary, be communicated to the Senate and House of Representatives of Congress, and to the President of the United States.

The Society has endeavored to enlist educators in the subject of metrological reform by circular communications addressed to the colleges and schools of the country setting forth the advantages to be anticipated from the substitution of the decimal system for derivation of superior and inferior denominations of weight and measure from the basic units, in place of the discordant, absurd and irregular ratios which now prevail, and in regard to which our own metrological system comes near being the most indefensible of any that has ever existed; pointing out also the immense benefit to the world which would result from the establishment of one common system of weight and measure for all mankind; giving the history of accomplished facts which show to what extent the metric system has already been established by law among civilized nations; and to what extent among non-metric as well as metric nations, it has become the system of scientific men and of scientific associations; and earnestly recommending to all the institutions addressed, that they should make the study of the metric system a part of their course of instruction, or exact a knowledge of it as one of the conditions of admission.

In concert with the American Metric Bureau, this Society has also made appeals to practical men, particularly to men engaged in scientific professions, to employ in their ordinary business transactions metric weights and measures in preference to those now in common use.

But while earnestly urging and ardently pressing every measure, whether of individual or of legislative action, tending to promote the introduction at the earliest practicable period of the metric system into general use among us, the Society has not been in accord with those who have been impatient for the passage just at this time of a law fixing a date in the near future from and after which the exclusive use of that system shall be compulsory. They have not been without apprehension that too precipitate legislation might lead to a revulsion of public feeling and consequent reaction. In their view it would be a grave calamity and one which might defer indefinitely the accomplishment of the desired reform, should such a law, after having been once passed, be subsequently repealed. Hence, when, in 1875, an invitation was laid before them from the Boston Society of Civil Engineers to unite in a petition to Congress praying for the immediate passage of an act to the effect just stated, they felt constrained to withhold their assent to the proposition, and in response to the invitation, adopted the following resolution: —

> *Resolved*, That it is the judgment of this Society that the time has not yet come when it is possible to fix a date for the compulsory adoption in all public and private transactions of a uniform system of weights and measures; — that present efforts should be directed towards the gradual adoption of the Metric System by the government for international purposes whenever practicable, and for the Postal and Customs services, and toward the instruction of the public in regard to the nature and advantages of the metric system.

The American Metric Bureau. — This is an organization of more recent origin and of a more practical character than that just described. It was established in July, 1876, with the object of diffusing among the people information in every practicable form in regard to the metric system, and of securing active coöperation on the part of teachers and practical artisans and manufacturers, with a view to the introduction of the system actually into use in work-

shops and in commerce. The means employed by the Bureau have been various, of which not the least effectual has been the preparations of circulars and placards explaining and advocating the system, or in some way calculated to advance its introduction, which, by gratuitous distribution, have been made to reach nearly every township in the United States. The Bureau early established a central office at Boston, where were provided collections of everything which could illustrate the international measures, and from which sets of metric weights and measures could be obtained to be distributed at cost-price to all applicants. There have been established by it also a considerable number of branch offices in different cities and towns in the United States, where similar collections have been maintained, and from which similar distributions have been made. Within the first year after its organization several hundred addresses were delivered by members of the Bureau, or by able speakers engaged by them.

The influence of the Bureau has also been successful in securing the publication and circulation of many hundreds of articles through the daily journals and periodical magazines, prepared with the special view of awakening the interest of the general reader in the subject, and of carrying information into circles which could not in any other way be so easily reached. Many committees from the Bureau have waited upon departments or branches of the State or National Governments, endeavoring to enlist the coöperation of men in public station in behalf of the cause. A very large number of schools have been visited and interested in the subject by committees, officers, and members of the Bureau. Besides securing the publication in the journals of the day of articles furnished by its own members, the Bureau has, in many instances, succeeded in engaging the editors of such journals themselves in the active advocacy of the proposed reform. The number of periodical publications in the country is not far from eight thousand. In most of these have appeared articles on the subject more or less extended, and more or less frequent. It may easily be conceived how thoroughly through this channel the Bureau has been able to address itself to the intelligence of the people, and how powerful must be the influence it is thus enabled to exert in shaping public opinion.

The Bureau has also conducted a very heavy correspondence with friends of the system in every part of the country, involving not only great labor but no slight expense. Its operations have, nevertheless, been conducted with great economy. It has sought no return for the various publications issued by it, in which have been included not only its own circulars and periodicals, but also many standard works relating to the subject, beyond what might be necessary to defray the actual cost of the distribution. The same is true in regard to the sales of metric measures and apparatus which have been made from its several depositories, the prices affixed to many of them being only half what the same articles cost at retail in the market.

The organization is, therefore, practically missionary in its character, and, but for the evidently great and growing interest in the subject throughout the country, it could not be maintained. The evidence of this interest, however, becomes every day so much more and more decided, that the managers of the Bureau have felt themselves encouraged to put forth continually increased effort, and to extend their operations from month to month more and more widely. Their membership is now very large, and embraces individuals in nearly or quite every State in the Union. From time to time meetings of the Bureau, and of others interested in the cause of metric reform, have been held at the head-quarters in Boston or elsewhere; and on these occasions many leading educators and others have made public addresses to large and intelligent audiences.

The following are portions of one of these addresses delivered at the annual meeting held in December, 1877: —

From the President's opening address at the annual meeting of the American Metric Bureau, Dec. 27, 1877.

It is now little more than a dozen years since the movement in favor of the reform of the confused metrological system of the United States was first set on foot. Originating with a few advanced thinkers, and regarded with indifference by the multitude, it encountered, as it is the fate of all efforts to emancipate mankind from the burden of traditional evils to encounter, a much larger degree of opposition than of encouragement or favor. Nothing indeed so promptly arouses the prejudices and jealousies of man-

kind as a seeming attack upon those existing institutions which time has made venerable. Men cling with affection even to the faults and imperfections of such institutions, because they are theirs, and because they were those of their fathers before them; and all is to his knowledge of the existence of this feeling, and his skill in the art of playing upon it, that the political demagogue owes so much of his power. It may be doubted, for example, whether all the ingenious sophistry which has been employed during the last twelve months to pervert the public judgment and demoralize the public conscience upon a grave question of legislation involving in its decision nothing less than the preservation or sacrifice of the national honor, has been half so effectual as the simple appeal to prejudice which lurks beneath the sentimental demand for the restoration of "the dollar of the fathers."

It was against this feeling that the movement in which we are interested had chiefly, in its early stages, to contend; but the same malign influence will always continue to confront it, until the object of the struggle shall have been completely accomplished. The contest was then, however, conducted under peculiar disadvantages, in consequence of the ignorance, almost universally prevailing among the people of this country, in regard to the subject of the controversy. Not one in fifty of our countrymen knew anything of the metric system of weights and measures, or had ever heard the name. And, paradoxical as the assertion may appear, hardly one in a hundred of them possessed any proper knowledge even of our own. In saying this I by no means intend to assert that they did not know the meaning of the word *foot*, or *pound*, or *gallon*, or *acre*. I mean only that they had no adequate knowledge of the merits or defects of the system to which the dimensions so named belong. Practically, they may be said to have been ignorant that the system had any defects. They had accepted it as it had been handed down to them, very much as they accept the climate in which they live, the distribution of land and water upon the globe, or of mineral wealth beneath its surface; as a part of the order of nature which it would be profitless to question. Certainly they were not ignorant of its details; certainly they experienced the inconveniences attending its use; but they lived in blessed unconsciousness that these details were full of absurdities, or that these inconveniences did not inhere in the nature of things.

Nor need ignorance of this description as to this subject excite surprise, when we reflect that, as a very frequent fact, men are found to know least of the things which they have known longest. There is, probably, nothing which any man can be said to know better than the language which he speaks. It was the earliest acquisition of his infant life, and he has been using it daily ever since. It is employed, if not with equal correctness, at least with equal facility, by the lettered and the unlettered alike.

But the unlettered rustic, notwithstanding his familiarity with his language in its uses, knows, after all, very little of its structure or its laws. He knows nothing of the classification of words, of conjugations or declensions, of cases, or genders, or numbers. He cannot tell whether his verbs are regular or irregular, nor whether irregularity is a fault or a merit; though he sometimes unconsciously substitutes one form for the other as in saying *shew* for *showed*, and *knowed* for *knew*. He cannot explain to you how plurals are regularly formed, though in parts of our country he sometimes reduplicates his plurals; as when he says *tomatusses* and *potatusses* for tomatoes and potatoes. Of course he is incompetent to judge how nearly his language approaches the ideal of a perfect instrument of communication, or how widely it departs from such a model, or whether in this respect it is better or worse than the languages of neighboring nations.

In a manner entirely similar, the majority of people acquire the knowledge they possess of the metrological systems to which they are born. They learn as matter of fact that three feet make a yard, and five and a half yards make a rod; that four quarts make a gallon, and thirty-one and a half gallons make a barrel; that sixteen ounces make a pound, and twenty-two hundred and forty pounds make a ton; that two hundred and seventy-two and a quarter square feet make a square rod, and one hundred and sixty square rods make an acre; that seventeen hundred and twenty-eight cubic inches make a cubic foot, that one hundred and twenty-eight cubic feet make a cord of wood, and that twenty-three and three-quarters cubic feet make a perch of earth or stone. These several measures, and all those of which they are examples, seem to such persons to exist, as do the sun and moon, by a certain sort of necessity. These persons seem to be saying to themselves, "You can't change the sun and moon, you know; you must take them as they are, whether you like them or not. How then can we change our acre, our wood-cord, or our pound?"

The agitation of the subject during the past ten years has done much, however, to remove, with very many of our fellow-citizens, this deplorably helpless frame of mind. The educated class have had only to reflect a little in order to become conscious of its absurdity. And the class of educators, who are an immense power in the land, have extensively engaged in the very effectual labor of endeavoring to prevent another generation from coming upon the stage of active life bound in the intellectual shackles which, in regard to this subject, have held the last in a slavery so pitiable.

The circumstances under which we are assembled to exchange greetings to-day are full of cheer. The prospect before us is in the highest degree encouraging. If it must be said that we have as yet accomplished little in the way of securing favorable legislation, it may, nevertheless, be added that we have accomplished much in

eliciting the outspoken sympathies and commanding the active a[illegible]d zealous coöperation of the most enlightened and most influential [illegible]of our fellow-citizens, of our educators, our statesmen, our jurists, o[illegible]r engineers, our architects, our merchant princes, our manufacturer[illegible]s, and our numerous organizations for the advancement of letters a[illegible]d science. A tide of favoring opinion has arisen, and, with each su[illegible]c-ceeding year, has been gathering strength, until its power has becom[illegible]e too formidable to be permanently resisted, and which will be su[illegible]re in the end to sweep along with it even the most inert of legislati[illegible]ve bodies.

In the meantime the metric movement in foreign countries h[illegible]s made a progress eminently satisfactory. All Central and Norther[illegible]n Europe has become identified with it, as Southern Europe had bee[illegible]n before, — the little peninsula of Denmark remaining the only ex[illegible]- ception.

Before the formation of the German Empire, a number of th[illegible]e States which now compose that powerful political organism ha[illegible]d taken some steps towards the reform of their local metrologica[illegible]l systems by giving metric values to their units of length and o[illegible] weight; but as their proceedings had been without concert, the re[illegible] sults were not harmonious; and the units adopted, though in simpl[illegible] relations with each other, were not identical. After the formation [illegible] in 1865, of the North German Confederation, these differences were [illegible] for all the States embraced in that compact, prospectively reconcile[illegible] by the enactment of a law designed to take effect on the 1st of January, 1872, adopting the metric system in full. In the mean[illegible] time the Confederation was superseded by the Empire, which date[illegible] its construction from April, 1871; but this important political event[illegible] instead of retarding, served rather to advance the progress of metrological reform; the Reichstag of the Empire having promptly[illegible] reënacted the law of the Confederation, and extended its operation[illegible] over North and South Germany alike. The example of Germany[illegible] was speedily imitated by Austria, where the use of metric weights[illegible] and measures became compulsory on the 1st of January, 1876.

From the Scandinavian countries of Northern Europe early favor-able action in the direction of this reform had hardly been looked for. So long ago as 1866 Sweden had introduced the decimal ratios into her system of length-measures and of weight-measures; and Norway had done the same as it respects length; but neither had adopted metric values. Progress of this kind, while evincive of a reforming spirit, tends, perhaps, in general to retard rather than to accelerate a radical change; for just in degree as a national system is divested of the imperfections which make it a daily bur-den and embarrassment to those who use it, in the same degree is the difficulty of replacing it by a new one increased. These coun-tries, however, have very agreeably surprised us. In Norway, after the 1st of January, 1878, now near at hand, the metric system of

weights and measures will alone be allowed in the transaction of business; and in Sweden a similar reform has been provided for by law, to be accomplished a few years later. Thus, over the entire area of the continent of Europe west of Russia — Denmark only excepted — there prevails but a single system of weights and measures; and when it is considered that, throughout this same area a century ago there still reigned a metrological chaos in which differing values of length-units, weight-units, and capacity-units, to say nothing of the endlessly varying multiples and submultiples of these things, were reckoned, not by dozens or by scores, but by hundreds; and that hardly forty years have yet elapsed since out of this chaos the first elements of order began to appear, we cannot but feel that here is a movement which, however it may be retarded by human prejudices and human obstinacy, is destined ultimately to sweep all obstacles before it, and bring to its triumphant fulfilment the famous prophecy of Mr. John Quincy Adams, that the meter shall yet surround the world in use as well as in multiplied extension.

. . . . . .

Indeed, the day is apparently not far distant when to its conquests already made the metric reform shall have added that of the great Russian empire also — an empire which, counting only its European population, embraces more than seventy millions of people, and in its Asiatic domains ten or twelve millions more. Its vast Asiatic territory, covering a fortieth part of the earth's surface, and a tenth part of all the land on the planet, rests, by its eastern boundary, upon the Pacific Ocean. When its rulers shall have reached a favorable decision, as we have reason to expect they will, upon the important metrological question, which, we are authentically informed, they were holding under advisement at the outbreaking of the present Russo-Turkish war, the single arc of the earth's circumference remaining to be filled up, in order that the meter may surround the world, will be that which it devolves upon our own people to supply.

We shall supply it; that cannot be doubted. How soon we shall supply it is a matter of more uncertainty. Strong as we are in the sympathies and active coöperation of the more intelligent of our countrymen, we are embarrassed at every step of our progress by an army of obstructives, who will spare no effort to prevent the accomplishment of our object. These obstructives do not all occupy the same camp nor fight with the same weapons. They may be distinguished into two principal divisions, of which the first consists of declared enemies, and the second of pretended friends. The declared enemies are those who frankly announce their intention to oppose us to the end. The pretended friends, on the other hand, profess a hearty concurrence with us in our principles, but withhold their assent from our modes of applying them.

They are zealous for reform, but doubt the wisdom of this particular measure. They admit the imperfection and the manifold absurdities of the existing system, and are clear that, somehow or other, it must be brushed out of existence. They are even gracious enough to allow that the metric system has some good points; but yet cannot bring themselves to regard it as quite the thing that is wanted. They say to us in substance, "This system is certainly ingenious, but it is not practical — it is not what the world wants. The four or five hundred millions of people who have adopted it are all wrong — they will have to abandon it in the end, and fall back upon something feasible."

Neither of the two classes above distinguished is entirely homogeneous; both have their subordinate divisions, — each pursuing its own line of operation or argument. Of the class avowedly hostile, the subdivisions are two, of whom the first are resolved that we shall not succeed, and the second declare that we cannot. The first take the broad ground that no change is needed, and that none ought to be tolerated. They deny that our existing system is seriously imperfect or inconvenient. They maintain, on the other hand, that it is a good system — good enough — more than good enough — possessed in fact of many valuable features which ought never to be relinquished, but which we, misguided metromaniacs, propose to throw foolishly away. The second assert that, whether our actual system is good or bad, — and they do not trouble themselves to deny that it is possibly as bad as its worst enemies assert, — the attempt to overthrow it is little better than tilting against windmills, and is doomed, from the beginning, to inevitable and inglorious failure. This system is so inwrought, they tell us, with the industrial system of the country, so identified with every material interest of the people, that the moment you touch it, chaos will come again, and a general rebellion is more than probable.

Though these two divisions of our opponents are at variance with each other as to the advantages or disadvantages of the present state of things, they are entirely harmonious in their resistance to any proposal to disturb it; and each, upon occasion, employs with vigor the arguments of the other. Those of the first class, however, rest their case mainly upon the merits of our own system, and upon the fact that it is ours. If, they say, the world wants uniformity, let the world come to us; that would be a proper and a just tribute to our superiority and our natural right to dictate. As for ourselves, we want no change, and least of all such change as would come from the corrupt inventions of the effete and decaying monarchies of the old world. They pray Heaven daily that the pure and invigorating breezes that sweep over the boundless plains of this great Western Continent may never be contaminated by the foul odors that come reeking up from the loathsome dungeons of despotism.

The French have a name for this spirit, which we have not, though we have the thing itself abundantly. They call it *chauvinism*. It would seem as though the Chauvins ought only to be found in the ranks of the uneducated and ignorant; but this is far from being strictly true. Men of even presumably high culture, and occupying conspicuous positions in society and in the state, not seldom adopt the logic, if they do not indulge in the rhodomantade, of the typical Chauvin. In evidence of this, it is only necessary to examine the arguments employed before the British House of Commons in the last important debate on this subject before that body, when, in 1871, a bill to make the use of the metric system compulsory throughout the United Kingdom after a determinate period of years was lost by the narrow majority of only five votes.

Mr. Stevenson, a large manufacturer of sulphuric acid, the champion leader of the opposition on that occasion, presented for example the following illustration of the happy adaptation of the British weights and measures to facilitate the operations of his own business. "I employ a tank," he says, "in which every linear inch of depth corresponds to a capacity of ten cubic feet, or every tenth of an inch to one cubic foot. A cubic foot weighs one thousand ounces. Putting the specific gravity of sulphuric acid at 1.6, a cubic foot of acid weighs sixteen hundred ounces, or one hundred pounds, and ten cubic feet one thousand pounds. I have only, therefore, to measure the inches of depth in my tank, and I have the weight of the contained acid in thousands of pounds."

Now, nothing is plainer than that this convenient property of Mr. Stevenson's tank is not due to the fact that the linear foot contains twelve inches, or the cubic foot one thousand seven hundred and twenty-eight cubic inches, nor that the cubic foot of water weighs a thousand ounces (which it does not), nor that the specific gravity of sulphuric acid is 1.6 (which it is not). This admirable property could be just as well secured if there were only nine inches in a foot, or eleven inches, or even a fractional number, as eleven and thirty-one forty-sevenths. The weight of a given volume of water, no matter what, being known; and the specific gravity of acid, no matter what, being given; then whatever be the unit of length, and whatever the ratio of the unit to the superior or inferior denominations of the same measure, it requires but a simple arithmetical calculation to determine the dimensions of a tank in which any assigned depth shall correspond to any given volume or any given weight of the contained liquid. A tank, for instance, twenty-five decims square, will contain one hundred kilos of acid at 1.6 sp. gr. for every linear centim of depth.

But sulphuric acid, in quantity, is estimated in tons. Mr. Stevenson rather ungraciously admits that here the metric system has the advantage. He says, "No doubt the Frenchman can turn

his kilograms into tons more easily than I can; for he divides by one thousand, and I divide by two thousand two hundred and forty; but I find no difficulty in keeping our accounts in tons and decimals of a ton." In this last remark we have the very essence of chauvinism. And so he "ventures to denounce as without foundation the statement of the Standards Commission of Great Britain, that the want of the metric system is not unfrequently felt by chemists and engineers of the highest class."

This spirit of bigoted preference for our existing measures, because they exist, is very strikingly manifested in the report of the Committee on the Metric System, of the New York University Convocation, made in 1870. The committee speak of the possible adoption of the new system as "a calamity by which we shall have blotted from the mind of the nation the foot, and all knowledge of every measure into which it enters as a unit; shall have expunged the yard used in connection with the arm more or less in every family; and the pace, the unit and guide of the farmer." Again they remark of measures of capacity, we shall have "the liter, the four hundredth part of a cubic foot, a unit quite too small for common measurements. Into this unit," they add, "merges one gill, one pint, one quart, one gallon, one peck, one-half bushel, and one bushel. These all disappear, and we measure in the liter and its multiples and sub-multiples."

And it appears to be possible that arguments like these, in which the measures with which we daze and bewilder every rising generation are treated as priceless possessions which it would be next to sacrilege to touch, can be gravely addressed to a large body of American educationists in convocation assembled, and received with respect, if not with approval, instead of being drowned in a flood of derisive laughter.

The Chauvins, pure and simple, however, are not so numerous in this discussion as are those others of our opponents who tell us, not that the thing we propose is wrong, but that it is impossible. In demonstration of this they overwhelm us with the multitude of examples in which articles ordinarily designated by their dimensions would be only expressible in decimals shocking in aspect and interminable in length. "Here, for instance," says Mr. Stevenson, "I have an illustrated sheet of hinges of many various sizes, and all these sizes are expressed in inches, and halves, quarters, and eighths of an inch. Are such names as two and one-half inch hinges to be illegal under this bill? If so, how will a workman recognize the size he has been accustomed to, when he wants to buy some more of them?" The practical conclusion which we are expected to draw from facts like these is that the thing we propose cannot be done; and yet, when we consider that no dimension expressed in inches can ever differ from the same dimension expressed in millims more than one-half a millim — a quantity quite inappreciable for ordinary

purposes — it does not appear that a two and one-half inch hinge may not just as well be called a sixty-three millim hinge; while probably, after a time, it will be supplanted by a sixty-millim or six-centim hinge, no one being the worse for the change.

Mr. Stevenson offers as further illustrations of the impracticability of our scheme, the probable perplexities which operative mechanics would suffer from its adoption. He says, for instance, that a sawyer who knows very well the size of a twelve-inch log, and what number of half-inch plank it will yield, can have no conception of a log thirty centimeters and five millimeters in diameter; or of the thickness of a board of one centimeter and twenty-seven millimeters. Why this ingenious gentleman should state thus particularly the exact metrical equivalent of the twelve-inch diameter is not very apparent, unless, indeed, he regards it as a law of nature that logs shall grow to exactly twelve inches. In point of fact, this term, "a twelve-inch log," is vaguely applied to logs varying probably from ten to fifteen inches; and, without danger of serious error, we may take a round thirty centimeters as its practical equivalent. Half-inch planks are cut, moreover, because there are half inches. Twelve-millim planks or ten-millim planks would generally do just as well; and it would really seem that a sawyer would not be obliged to cut up more than five or six hundred logs, or to spend more than six or eight months of his life, in learning how many ten-millim planks may be obtained from a thirty-centim log. So with Mr. Stevenson's carpenter, who knows a joist nine inches by three when he sees it, but who would not know it as 22.86 cms. by 7.62 cms.; so also with his plumber, who can understand a sheet of lead five pounds to the square foot, but fails to recognize the same when stated as 2.25 kilograms to 9.29 square decimeters. The carpenter's joist would, under the metric system, be expressed, not in the metric equivalents of inches, but by convenient round numbers of centims or millims. Thus we might have twenty-three by eight centim joist, or twenty by seven, or twenty-five by nine; and instead of five-pound lead, meaning five pounds to the square foot, we should have twenty-five-kilo lead, that is, twenty-five kilos to the square meter, which would be almost exactly identical in character with the former.

Some of the difficulties made by these objectors are simply laughable. For instance, Mr. Stevenson says that, inasmuch as candles are rated as sixes or eights — meaning six or eight to the pound — the housewife will be at a loss what name to employ to express her accustomed size of candles, and "how she is to know if her six candles weigh a pound when the weight is illegal and unknown." This implies that the housewife does actually know that her six candles, purchased at present under the name of sixes,

weigh really a pound. If it is true that she knows this, she must be a very knowing housewife.

And here it may be proper to remark that, in regard to a very large proportion of the purchases which men make, they have, and, under the established usages of trade, they can have only the vaguest notions of the quantity they are buying. Wine, table-oil, ink, mucilage, cologne-water, hair-dye, patent medicines, dinner-sauce, mineral water, and many other liquids, are sold by the bottle; pickles, preserved fruits, olives, etc., by the jar; sardines, guava-jelly, lucifer matches, etc., by the box; strawberries by the basket, radishes by the bunch, onions by the string, and so on. Gloves, also, and shoes are rated by numbers and not by inches of length. To the argument, therefore, that it would be impossible to buy and sell in the petty business transactions of daily life, unless we have a distinct idea of the exact amount we are buying and selling, it may be replied that this is contrary to experience, since we are doing it all the time. Who knows what is meant by a bottle, a basket, or a box? Or rather, who does not know that the size of the bottle depends very much on what there is in it; and that the internal capacity of this vessel is generally widely at variance with its external appearance, having been, with evident design, gradually reduced by the indentation of the bottom, until many descriptions of bottles occupy nearly twice the space necessary for the accommodation of their contents?

Another hallucination of our opponents is manifested in the continual parade they make of the fractional forms in which quantities will have to be expressed if we discard our actual weights and measures for the metric. Should we desire, they say, to do so simple a thing as to order a few yards of cloth for a coat, or a few pounds of meat for dinner, we shall have to annex to the approximate number of meters or grams named, a decimal tail of appalling length. According to them we shall be always compelled to buy the same absolute quantities under any system of metrology. They speak of our pounds and yards and gallons as if these were the embodiment of certain archetypal ideas, like those in Plato's philosophy, existing from necessity; so that, whatever our metrological scale, these absolute units and their multiples and submultiples will be the things with which, at whatever sacrifice of convenience, we shall have actually to deal. But when it is pointed out that the objective quantities with which we are concerned in the daily transactions of business are determined entirely by our artificial metrological scale itself—that there is no reason to regard them as possessing any special quality of convenience—and that they naturally change with change of scale to such an extent as to remove all the perplexing fractional expressions with which our opponents seek to alarm us, this seemingly formidable

objection suddenly collapses, and we perceive that it never had any existence except in the imagination.

Among the arguments urged by those who maintain the impossibility of change, one only appears to have much force; and that is the argument drawn from the dependency of machinery upon minute exactness in the measurement of parts, and from the great expense which would attend the adaptation of machine shops and machines to a new system. For a shop employing two hundred and fifty men, this expense, according to Messrs. Sellers and Tatham, in their report to the Franklin Institute, would amount to no less than one hundred and fifty thousand dollars, or six hundred dollars per man. The committee of the New York University Convocation, in their second report (1872), have taken the pains to explain that, in a twenty-five-horse steam-engine, there are four hundred and sixty-eight parts in all, including one hundred and forty-seven of different kinds; that in determining the forms of these there are two thousand nine hundred and forty different dimensions, one thousand three hundred and twenty-nine of which are expressed in exact inches and the rest in inches and fractions of one-half, one-fourth, one-eighth, and one-sixteenth.

Singularly enough, these statements and all the rest of the same class in both the reports referred to, instead of being arguments against the abolition of the present metrological system and the substitution of the metric for it, afford the strongest reason for believing that that is precisely the thing which ought to be done. We desire, I suppose, to create a demand for our steam-engines and our manufacturing machinery on the continent of Europe. Such a demand, to a certain extent, exists already. We have sold not a few locomotives to Russia — some perhaps to other countries. Many American sewing-machines, and many agricultural implements, have been sold in every European country. Since the Exposition of 1876, the whole industrial population of Europe have been wide awake to the value of our numerous mechanical inventions, previously hardly known abroad at all. But a steam-engine or a machine all of whose parts are measured in English linear measures, if transferred to a metric country, and there by accident disabled, becomes nearly useless, since the shops of such a country afford no facilities for repairing it. And what is true of machines is true of the products of machinery. If we wish our augurs and chisels, our bits and screws, our butts and hinges, objects on which our opponents hinge so large a portion of their argument, to be freely purchased by continental traders, and freely employed in continental dwellings, we must cease to make them, and cease to call them two and one-half inch butts, one and one-fourth inch butts, one inch butts, and so on; but must make and call them six centim butts, three centim butts, twenty-five millim butts, instead.

When, therefore, our opponents tell us that we cannot afford to

do this thing because it will cost us so much, I reply that we cannot afford not to do it because that will cost us so much more.

If from that class of obstructives whose unfriendliness to the object we have in view is undisguised, we turn to the other, characterized above as pretended friends, we shall find that this also is made up of subordinate classes whose ways of thinking are various. Some of these, while professing to be greatly enamored of the metric system as a system, and regarding as quite correct in principle the derivation of its linear base from a dimension constant in nature, still object that a serious error has been committed in the selection of this dimension. It is true that all who hold these views are not agreed among themselves as to what selection would have been better. A portion of them incline to the seconds-beating pendulum. Such a pendulum is invariable in length, at least for the same locality. It is an object which we can directly observe, and which, according to the common opinion, it must be a very simple business to measure. I suppose it to be generally believed that the knowledge we have of the length of the seconds' pendulum has been obtained by such direct measurement. But this is not true in the least. The received length of the pendulum is a mathematical deduction from observations on the fall of heavy bodies, or on the motion of the moon in its orbit. And the theoretic pendulum contemplated in this deduction is not the more or less ponderous and bulky body we see vibrating in the clock-case, but a mass without magnitude suspended by a rod without weight, — unaffected, moreover, by fluctuating temperatures or by variations of atmospheric resistance. In the concrete instrument, this ideal pendulum is represented by the distance from the point of suspension to the centre of oscillation. The first of these points is definite enough, but the second cannot be fixed in any ordinary material pendulum, with the precision required for the purposes of a standard. An apparent solution of the difficulty is found in Kater's reversible pendulum, which is provided with adjustable knife-edges upon which it may be made to vibrate with either end uppermost. When the time of vibration is the same in both positions, the distance between the knife-edges is the measure of the theoretic pendulum. The idea seems simple enough; but it is simple only to those who have never attempted to rate a pendulum on, under circumstances which make it practically impossible to eliminate the influence of temperature and the disturbing effects of varying atmospheric density. Its unavailability as a practical method was clearly recognized in Great Britain forty years ago, when, after the destruction of the government standards by fire in 1834, it was deliberately rejected in the reconstruction, though it was the method prescribed by law.

Another class of objectors to the meter as derived from the terrestrial meridian have proposed to substitute for it the ten mil-

lionth part of the earth's polar semi-axis. Of this proposition, in favor of which may be cited the names of men worthy of every respect, like those of Sir John Herschel and Prof. Piazzi Smyth, it can only be said that, whatever be its merit, it comes too late in the day to have any other effect than, by distracting opinions, to retard the progress of metrological reform. Moreover, the preference for this proposed base seems to rest on sentimental rather than on practical grounds; and it is difficult to discover any substantial advantage which could be gained by the substitution.

There are others again who are content enough with the ten millionth of the quadrant as the linear base of the system, but who cannot be reconciled to the meter, because, as they tell us, it is *not* the ten millionth of the quadrant. The people who make themselves unhappy about this matter are probably without the slightest conception of the minuteness of the alleged inequality which gives them so much concern. They are probably unaware that if they were to take into their own hands two similarly formed meter bars differing in length by the infinitesimal amount of error which some industrious mathematicians, upon very inadequate data, have imagined themselves to discover in the standard meter of 1799, they would certainly find it difficult and, probably, impossible to distinguish between them. They are probably unaware that, as the meter is standarded at the temperature of freezing, its expansion in rising to ordinary summer heat is greater than this trivial imputed error; so that, even if the error is real, the meter in actual use is as often too long as too short. They are probably unaware that of the foot rules and yard measures which are actually in use among mechanics and tradesmen, hardly one in a hundred can be found which does not differ from the legal standard in this country more than the meter of 1799 differs from the ideal meter of the mathematicians. And they shut their eyes to the fact that the mathematicians are not agreed among themselves about the magnitude of the difference; and are even obliged to confess that after all, owing to the meagreness of their data, this trivial error they impute may be itself an error, and that the error of the meter, of which we hear so much, may possibly prove, in the end, to be without existence.[1]

Let it be granted, however, that the mathematicians may at some time or other establish conclusively that the meter is not exactly the ten millionth part of the quadrant, they will then, by virtue of the very same process, have demonstrated that it is in some other definite ratio to the same terrestrial dimension — possibly the ten millionth and fifth, or the ten millionth and seventh — that is to say, they will have connected it as certainly and as positively with the unalterable standard furnished by the earth's

[1] See note on this subject at the end of Section Third.

circumference as if the exact decimal ratio had been maintained. Nor will this interfere with the uniformity of the system, for though the system is decimal, the earth's quadrant or the earth's circumference is not a denomination of the system, nor is it ever involved in any metrical computations — not even in those of astronomy.

It may seem a waste of breath to dwell upon this frivolous objection, but it is certainly, in the minds of many, a serious obstacle to the acceptance of the metric system; and, to my astonishment, I have heard it often in the mouths of persons for whose good sense as to other matters I have the highest respect. Almost with equal surprise have I observed that the same persons, while thus professing themselves to be dissatisfied with the meter which we have, because of its alleged uncertainty, are generally in favor of a new meter to be derived from the earth's axis. The meridian meter, right or wrong, is at least founded on positive measurement. We *can* measure the meridian, in part at least, if not in whole; but the axis is totally inaccessible, and all we can ever know of its length must be mere inference from the results of those very meridian measurements from which we derive the actual meter.

There are others, however, who attach no importance to the refinements of mathematical speculation over the true length of the meter, but are, nevertheless, a good deal troubled with apprehensions of the serious consequences which might follow the possible loss, in the confusion of civil convulsions, or, as in Great Britain, forty years ago, by fire, of the original prototype standards. In such a case, according to these timorous thinkers, there would be no possible remedy for the calamity but in a renewal and repetition of the immense labor of the last century, of measuring a great arc of the meridian,— a labor involving vast expenditures of money and occupying years of time. But when it is considered that the accuracy of the great trigonometrical survey of the French arc was dependent wholly upon the accuracy of the mechanical measurement of certain base lines of not more than ten or fifteen kilometers in length, and that the termini of these base lines are marked, and will always continue to be marked, by fixed and unalterable monuments, it will at once be obvious that these bases themselves are standards from which an indefinite number of meter bars may be derived, all having precisely the same character for authenticity with that which is now the recognized standard in the Palace of the Archives at Paris. These bases were originally measured in toises, — the standard toise having been the identical bar used by La Condamine in the measurement of the South American meridian arc in 1735, and known as the toise of Peru. The result of the survey was to give a value of the terrestrial meridian quadrant expressed in toises. The division of this value by ten millions gave the length of the meter as a fraction of a toise; and the length of the meter being known, that of the originally measured bases

became known in meters. Let one of these bases be again measured in terms of any arbitrary unit assumed for the purpose, and let the length ascertained in such terms be divided by the known number of meters in that base, and the length of the meter is once more established — first, in terms of the arbitrary unit, and, secondly, by actual reconstruction in the form of a solid bar. It need hardly be said, however, that even this elaborate proceeding would be by no means necessary in order to repair the misfortune supposed. Too many copies of the meter of the Archives, verified with the most scrupulous care, and certified as to their accuracy by the official custodians of the standards and of eminent experts employed to assist in the comparisons, have been distributed throughout the civilized world, to make its prompt restoration, if lost, a matter of the slightest uncertainty or difficulty.

There are still others, however, who, considering the doubts which it will always be possible to raise in regard to any linear base derived from a dimension fixed in nature, are disposed to discard the idea of any such natural standard, and to adopt something entirely arbitrary. These naturally say that, by departing, in imitation of the French, from units of measure which use has made familiar, in pursuit of an idea which can never be realized, we are merely indulging a pleasing illusion accompanied by no clearly definable practical advantage. The decimal ratios of the metric system, on the other hand, and the interdependence of all its measures of length, surface, capacity, and weight, are admirable features totally independent of the particular length of the base. Why not adopt these features and adapt them to our own length unit? In attempting this, we may hope to secure something like unanimity among our people; but when you demand that they shall adopt the meter also, you will never persuade them to listen.

To this we may reply, first, that the resistance of our people to the introduction of the metric system, is no more a resistance to the metric base than to the metric ratios. These ratios are just as unfamiliar in practice as the base, and do just as much violence to established habits of thought. The proposition, therefore, is to require of our people to submit to whatever of inconvenience there may be in destroying their own system of weights and measures and introducing a new one, without after all securing the greatest advantage which such a change might bring, viz., harmony with other nations; and for this loss no compensation is offered them but that of preserving a single familiar measure, while all the remaining measures to which they have been accustomed, amounting to some scores or dozens, are swept out of existence.

A troublesome question may also arise as to what this single familiar measure so preserved shall be. The yard is the present legal standard. Shall we preserve and decimalize that, abolishing

the foot and the inch? In that case the carpenter and the machinist, and in fact the whole industrial world, lose their accustomed units, and all the practical evils which have been so eloquently described as likely to follow the introduction of the meter into the workshop, are precipitated upon us, while the grand compensating advantage of international harmony is not in the least provided. Shall we decimalize the foot, and take that as our unit? Still, Mr. Stevenson, we fear, will continue to grieve over his lost two and one-half inch hinges, and the unhappy sawyer of his visions will weep over his half-inch plank which he shall saw no more forever. Prof. Piazzi Smyth has expressed his preference for the inch. Shall we be guided by him? In that case, the carpenter, the linen-draper, the silk merchant, the farmer, the surveyor, the engineer, and the navigator, are all at sea at once; and, in the affecting language of the report to the University Convocation, "the foot, and all knowledge of every measure into which it enters as a unit, are blotted from the mind of the nation." The probabilities, I suppose, are that the foot is the dimension which would ultimately be fixed on as a base; but it is patent without reasoning that, with such a base, decimal sub-division would be just as unacceptable to objectors like Messrs. Stevenson, Sellers, and Tatham, as the metric system itself.

. . . . . .

But supposing all these difficulties disposed of and brushed completely out of the way, and supposing our people brought at last heartily to concur with us as to the desirability and the wisdom of the change we propose, it does not follow that our work is even yet completed, or that the hour of our triumph is come. The sluggishness of great masses is proverbial The tardiness with which they move even in the direction toward which interest and the sense of duty unite in pointing, is matter of familiar observation. And besides this, in many minds, after the importance and even the necessity of change have been fully admitted, there still remains lurking a vague apprehension of the temporary embarrassment and confusion which change may bring with it, sufficient to paralyze resolution, and arrest decisive action. These difficulties must not be permitted to discourage us. The inertia of the masses must be overcome by vigorous agitation, and the apprehension of confusion during the period of transition must be allayed by appeals to common sense. Any one who has made even a brief visit to a foreign country, is perfectly well aware that, after the first day or two, the novel weights, measures, and moneys to which he is introduced, cease to occasion him serious inconvenience. Most sensible persons, therefore, if asked why they should apprehend confusion and trouble from the adoption of a new system of metrology, will reply that it is not on their own account that they are anxious, but on that of their numerous fellow-citizens. Yet why should any

other individual be more inconvenienced than they? And why should there be serious embarrassment in a community, if each member of the community is personally free from embarrassment?

It may be replied, however, that the argument is here drawn from the case of persons of presumed education and superior intelligence; while the application is made to the educated and uneducated, the intelligent and unintelligent, alike. Take, then, a different case to which certainly no such objection can be alleged. In every year that passes we see arriving in our seaports hundreds and thousands — sometimes even hundreds of thousands — of immigrants from France, Germany, and the Scandinavian countries of Europe, who certainly do not represent the education, the culture, or the superior intelligence of the lands which they have left. They are introduced without the slightest preparation to our systems of weight, measure, and money. They fall in at once with our customs, our usages, our habits. Many of them engage in the practice of mechanic arts in which they are compelled to use our inch, our yard, our gallon, and our pound, almost from the day of their arrival. Who has heard of any serious inconvenience resulting to them from this abrupt modification of all the methods of measuring quantity to which they have been previously accustomed?

I insist, therefore, that these so often-expressed apprehensions of embarrassment to arise from the change of our metrological system, are gross exaggerations, the creations of the imagination never likely to be in any serious sense realized. Those who disagree with me in this sometimes attempt to argue from what they assert to have been the difficulty of eradicating from men's minds the old systems of colonial money in this country, the language of which continued to be used for at least a quarter of a century after the adoption by law of the dollar as the money unit; but it is simply not true that these currencies were remembered to the disadvantage of the Federal money, — a money which was perfectly understood and cordially adopted from the beginning. It *is* true, however, that the dollar at once completely superseded and drove out of use the pound, the money unit previously in use; and that the terms *shilling* and *penny* so far as they continued to be heard, were employed to express subordinate parts of the dollar.

The battle, therefore, will not be wholly won, even after the great majority of our countrymen shall have been convinced. It will still remain for us to prevail on them to have the courage of their convictions, and to act as well as to assent.

There are some, I am aware, among our friends, who, impatient of still existing popular prejudices, and indisposed to deal tenderly with the timidity and hesitation which may follow their removal, would resort in this matter to heroic treatment, and invoke from our national legislature a summary and sweeping measure of re-

form. A petition is already I believe before the present Congress, asking that after a definite day to be now fixed by law, the metric system of weights and measures shall alone be tolerated in the United States. Had we a government from which positive action of any sort on any subject could be reasonably expected under any influence short of that of an irrisistible popular demand, this mode of proceeding might possibly be wisest and best. It is not necessary to deny that the results, should it succeed, might vindicate its wisdom, in order to justify the belief that to pursue it would, nevertheless, be to expend effort fruitlessly, since it is sure to fail.

There are some of us who have better reason than others to know how profoundly unimpressible is the average Congressional mind in regard to any subject unconnected with the struggles of parties, or with the political chances of individual members in their own several states or districts. The members of the American Metrological Society have for years been earnestly praying Congress for certain simple acts of favorable legislation, which, as touching only indirectly the industries of the country, and where touching at all, touching only so as to be felt beneficially, could not possibly, as would a bill for the introduction among us of the metric system exclusively, provoke an active opposition; and for all these years they have been praying in vain. The simple measures referred to as embraced in their prayer, were that we may have the benefit of the metric system in the post-office, in the customs service, in the coinage, in the great governmental surveys, and in all public documents involving statements of quantity. In these petitions the society have had the cordial concurrence and cöoperation of multitudes of our most enlightened fellow-citizens, especially in our great commercial towns. I know of no instance in which any large importing merchant or banker has hesitated to affix promptly his signature to such a petition, when the opportunity has been presented to him. In one instance, in the spring of the year 1874, hundreds of names were obtained in the city of New York, by a single canvasser, in the course of two or three days; and these were names representing hundreds of millions of dollars. The numerous petitions prepared and signed in the year just named were all duly forwarded to Washington, and all duly presented in the House of Representatives, and all duly referred to a committee, and were afterwards never heard of more. But the fact of simple silence does not express the whole of the ignominy which befell them. They were not only never heard of more, but were never more seen. On the expiration of the Congress, the petitioners sought to recover them, that they might be renewedly presented to the Congress following. A diligent search was instituted through every corner of the committee-room, and through every pigeon-hole of the committee's desks, resulting in a failure to detect the slightest trace of their existence. Not content with this, the petitioners

ursued the members of the committee to their homes with demands
or information. The gentlemen were as ignorant on the subject
s the petitioners themselves. What then was the probable fate
f those voluminous documents? There can be but one answer:
ey were consigned to the waste-paper basket. And such are the
iscouragements which American citizens, seeking to promote a
easure which, though of universal public interest, is wholly un-
onnected with the political struggles of the day, have to encounter
om their so-called representatives who fail to represent them at
e national capital. Were there a question of the removal or reten-
on in office of a tide-waiter on the coast of Alaska, or of the
ppointment of a postmaster at the Confederate Cross Roads, no
oubt the attention of the assembled wisdom of the nation would
e unremittingly concentrated upon that important matter till dis-
osed of, even if it should take all summer or all winter to settle
; but when the thing proposed is one which concerns only the
ood of the people at large, involving no possibility to the politi-
an of gain in power or pelf, it is expeditiously consigned to the
blivion of the committee-room, and the document which pleads in
s favor lights the committee's cigars or kindles its fires.

Let, then, those that will, call upon the Congressional Hercules
help them; my belief is that our best hope of success is in help-
g ourselves. This Metric Bureau, and this great body of teachers
—there is more of hope at this time in instrumentalities like these,
an in scores of Senators or wagon-loads of Congressmen. Con-
ress never leads popular opinion, but never fails at last to follow
. Our appeal to be effectual must, therefore, be to the people.

That is the appeal which this Bureau was organized to make.
he impression which the Bureau has produced upon the public
ind, during the brief period since it commenced its operations, has
en so signal as to have astonished even the most sanguine of its
unders. I congratulate you, gentlemen of the Bureau, upon the
bstantial successes which you have already achieved, and upon
e cheering prospect which the future holds up before you. Your
ccesses have been due in large measure to the very practical char-
ter of the instrumentalities you have employed. The weights and
easures you recommend you have placed before the people in
sible and tangible form. Instead of dwelling exclusively on the
eoretic perfection of the system, you have given palpable illus-
ations of its superior convenience. And in inducing manufactur-
s to adopt it in their constructions, and tradesmen in the daily
fairs of business, as in so many instances you have already done,
ou have created a sort of unorganized society of the propaganda
hich will grow in power with every succeeding year, and which,
surely as time goes on, will at length accomplish the object
e have in view, even though Congresses should be forever indif-
rent, and favoring legislation forever denied us.

You have done wisely, also, to associate yourselves with the educational organizations of the country. With the great body of teachers in the land enlisted in this cause, no power can be strong enough to prevail against it. The resistance which the metric movement encounters from the present generation is owing to a bias of the judgment received in early life, and deriving its force from early associations. The twig was bent too long ago to permit a complete correction of the distortion. If the teachers are with us, however, the next generation will look upon this question with very different eyes; and a success which it may not be permitted us to see will surely come with them. To the teachers, therefore, I would say, Your opportunity is golden, and your responsibility is great. No man, sensibly looking at the history of the past century, can possibly doubt that, in the words of Mr. Adams, a single language of weights and measures is yet to be spoken from the equator to the poles. And no one can question that, in order to this, either the extremely defective system employed by us at present must prevail, and the great metric wave now enveloping half the globe must be rolled back, or sooner or later our own system must give way and be swept out of sight. The whole civilized world has no third system which can come into competition with either of these. It is for the teachers of this country to impress upon the tender minds of the young these palpable truths, and make them clearly understand that it will largely rest with them to decide whether the great blessing of uniformity in the instrumentalities for facilitating the intercourse of nations shall be early secured, or whether, to the misfortune of mankind, its attainment shall be postponed to a remote period in the distant future. But let the teachers inculcate this lesson faithfully, and no further postponement need be feared. The duty which our hesitating and reluctant generation fails to perform will be accomplished by the next; and long before they shall have passed off from the scene of active life, the meter surrounding the world shall not only bind together the material interests of all nations, but shall also, let us hope, become an important instrumentality in promoting throughout the world the reign of universal harmony and peace.

Action of Scientific and Professional Associations, and of Educational Institutions, Favoring the Metric System.

The interest manifested in our country in favor of the metric system by associated bodies or public institutions, has not been confined to the organizations formed expressly and exclusively for the purpose of promoting metrological reform. Many others,

pecially those which have for their object the advancement of ience in general, or the improvement of particular scientific pro- sions, have occupied themselves very much with the same sub- t. Many of the institutions for higher education in the United ates have participated in the same effort. In the report made the House of Representatives in Congress, in the spring of 1866, the Hon. John A. Kasson, chairman of the Committee on inage, Weights, and Measures, mention is made of "various morials of universities and colleges," all of them recommending "the metric decimal system." One of the earliest of these in- tutions to act on the subject was Columbia College, New York, m which, in May, 1864, a petition was presented praying for s reform, in which the trustees and faculty both united.

The National Academy of Sciences. — In the year 1863 the ject of metrological reform was brought before the National ademy of Sciences, by a communication addressed to that body Mr. Chase, then Secretary of the Treasury, asking for the ap- ntment of a committee to consider and report what modifica- ns ought to be introduced into the system of weights and asures in use in the United States, or what system ought to be stituted for it. A committee was appointed accordingly, which, r holding the subject for some time under advisement, finally orted, in January, 1866, in favor of the ultimate adoption of the ric system, and also in favor of immediate legislation for the oduction of that system into the post-office and the mint, and the construction and distribution of metrical standards. This ort, which was very brief, is in the following words: —

he committee are in favor of adopting, ultimately, a decimal system; and, heir opinion, the metrical system of weights and measures, though not out defects, is, all things considered, the best in use. The committee, efore, suggest that the Academy recommend to Congress to authorize and ourage by law the introduction and use of the metrical system of weights measures; and that with a view to familiarize the people with the system, Academy recommend that provision be made by law for the immediate ufacture and distribution to the custom-houses and States of metrical dards of weights and measures; to introduce the system into the post- es by making a single letter weigh fifteen grams instead of fourteen and nteen-hundredths, or half an ounce; and to cause the new cent and two- t pieces to be so coined that they shall weigh, respectively, five and ten

grams, and that their diameters shall be made to bear a determinate and simple ratio to the metrical unit of length.

This report was among the influences which led to the enactment of the statutes of July, of the same year, relating to this subject, as already given (p. 234).

It was also in consequence of the recommendation in the conclusion of the report, that the act of May 16th following was passed, authorizing and directing the coinage of a five-cent nickel piece of the weight of five grams, to which was also given the diameter of two centimeters.

At the meeting of the Academy next following the passage of the acts just referred to, which was held at Northampton, Mass., in August, 1866, the following resolutions were adopted expressive of the gratification with which that body had received the intelligence of this very encouraging action on the part of our national legislature.

Resolved, That the National Academy of Sciences has heard with great satisfaction of the passage by the Congress of the United States of a law authorizing the employment of the metrical system of weights and measures; that in the opinion of the Academy such legislation is honorable to our country as identifying it with the scientific progress of the age.

Resolved, That the National Academy of Sciences earnestly recommend to the State officers having charge of the subject of public education to require the employment of the metrical system in works on arithmetic and other branches of science taught in the public schools, and to take such other measures as may insure the introduction of the system by educating the people to appreciate its advantages.

Returning to the subject in the month of January next ensuing (Jan., 1867), the Academy renewed the expression of its earnest desire that the rising generation of the country might be made intimately acquainted with the principles of this admirable system of metrology which had now received the sanction of law, by the introduction of the study of the system into the educational institutions of every grade throughout the United States; and expressed at the same time a hope that the people might soon be permitted to enjoy the benefit of metric weight in the post-office, which the act of the preceding July relating to that matter had authorized

the postmaster-general to provide. The resolutions adopted on this occasion were in these words: —

Resolved, 1. That the National Academy of Sciences is deeply impressed with the importance of educating the community, and especially the youth of the country, in the principles and use of the metric system of weights and measures now permissively established by law.

Resolved, 2. That in the opinion of the Academy no measure promises so certain success to this end as the introduction of the study of the system in the common schools of the country, and the explanation of the system to school teachers by competent persons.

Resolved, 3. That it be recommended to universities and colleges to make the metrical system of weights and measures a subject of examination and a necessary qualification for admission to those institutions.

Resolved, 4. That the Academy considers it highly desirable that the discretionary power granted by Congress to the postmaster-general to use the metrical weights in the post-offices be exercised at the earliest convenient day.

In order that the final resolution of this series might not remain upon their minutes as merely the empty expression of a sentiment, the Academy, at a subsequent meeting (Jan., 1868) appointed a special committee of three to wait upon the postmaster-general and respectfully to represent to him the deep interest they felt in the subject, and to urge upon him the early adoption of active measures to carry out the obvious intent of the law of 1866 in regard to postal weights. An oral report was presented from this committee, of which the following memorandum appears upon the record: —

The committee reported that they had waited upon the postmaster-general and communicated to him the action of the Academy; that he listened very courteously to their presentation of the reasons for adopting the metric scales, and that his directions to the chief clerk in their presence give them strong reason to believe that the action of the department will be in accordance with the recommendation of the Academy.

Notwithstanding, however, the gratifying assurances thus apparently given to the committee, the department remained wholly inactive in regard to the matter, and so has continued to remain under all subsequent changes of administration down to the present

time. The misfortune has been that we have never had a postmaster-general in cordial sympathy with the objects of the law, or manifesting any evidence of interest in the general subject of metrological reform. As a member of the General International Postal Union the government of the United States has been obliged to provide and to use metric balances and metric weights in the great seaport towns, in which the largest portion of the foreign correspondence of the country originates; but citizens of this country resident in the interior are not as yet allowed, though five years have elapsed since the ratification of the postal treaty, and thirteen years since the enactment of the statute of 1866, to enjoy the benefit of similar provisions even for their foreign correspondence.

The committee of the Academy originally appointed as above stated in 1863, has been continued in permanence ever since, and has, from time to time, presented reports and recommended action on subjects of metrological interest always conceived in the liberal spirit manifested in the foregoing resolutions. When, in 1873, the question of participation on the part of our government in the diplomatic conference proposed to be held in that year in the city of Paris, for the purpose of creating an International Bureau of Weights and Measures, was under consideration by the President of the United States, the Academy were called upon (as has been already stated, p. 243), for an expression of opinion as to the importance of the proposed institution and its relations to scientific progress, and also as to the expediency of accrediting a representative of the United States to the proposed Conference. The call was addressed through the Secretary of the Treasury, Mr. Boutwell, to Prof. Henry, the President of the Academy, and was by him referred to a select committee, composed, in great part, of members of the permanent committee above mentioned. The committee promptly presented the following report, which proved to be entirely satisfactory; and by inducing the President to respond to the invitation of the French government, led to that subsequent action by which the United States became a member of the great union of civilized nations for the perfection and preservation of the world's standards of weight and measure: —

To JOSEPH HENRY, LL.D.,

President of the National Academy of Sciences: —

SIR, — The undersigned, "Committee of the National Academy of Sciences," appointed by you as president, in compliance with a request of the Secretary of the Treasury of the United States, made in a letter transmitting for examination and report certain papers relating to a proposition on the part of the government of France for the establishment of an International Bureau of Weights and Measures, have attended to the subject referred to them, and beg leave to report as follows: —

The proposition of the French Government mentioned above, which is addressed not only to the government of the United States, but to all other governments with which that of France is in diplomatic communication, has been made in response to a resolution of the International Metric Commission of 1870–72, adopted at the conclusion of the final session of said commission in the year last mentioned. This international commission, in which were present the accredited representatives of thirty different nations, was originally called for the purpose of considering the condition of the prototype standards of the metric system of weights and measures, now deposited in the Palace of the Archives in Paris, and the expediency of replacing these by other standards exactly copied from them, or corrected for the exceedingly minute differences supposed to have been detected between them and the natural dimensions from which they were derived, to serve in either case as new prototype bases of the common system of metrology of the metric nations. Such being its declared object, the deliberations of this assembly might not at first view seem to have possessed any important interest to nations among whom the metric system has not yet been received, and accordingly the participation in its proceedings of delegates from such might appear to be due to no more earnest motive than the spirit of international comity, or a mere feeling of scientific curiosity. It is true, nevertheless, that whatever concerns the exact determination and the permanent preservation of the standard bases of any system of metrology is important to every people who may be in relations of friendly intercourse with that in which such system is in use, since any uncertainties or errors which may exist in regard to them, if gross, will introduce confusion into the affairs of commerce, and, if only slight, will vitiate the results of scientific observations, and deprive of value the most careful and patient labors of the investigator.

In regard to the metric system these propositions are especially true, since this system has become the only legal system of weights and measures for more than one-half the civilized world. It has been adopted wholly or partially by all the nations of Continental Europe, except the Russian and the Scandinavian; by Mexico, and all South America; and by British India, with her one hundred and fifty millions of inhabitants. In Great Britain, since 1864, its permissive use has been legalized, and the effort to introduce it as the exclusive system in that country — an effort which, on one or two

occasions already, has been nearly successful in Parliament — has been prosecuted from year to year with constantly increasing activity. The Royal Standards Commission, appointed in 1868, of which the astronomer royal was chairman, reported in the following year, recommending the introduction of the system in the United Kingdom, and their report was accompanied by an elaborate argument from W. W. Chisholm, Esq., warden of the standards, in favor of the recommendation.

In the year 1855 there was formed in London, with an extensive membership in the country, an organization designed to advocate the introduction into England of a uniform decimal system of weights and measures, which organization has ever since been earnestly urging the adoption of the metric system; and the British Association for the Advancement of Science has for many years maintained a standing committee, called the metric committee, of which the object is the same. The chambers of commerce of the principal towns in England, many farmers' clubs and workingmen's associations, and many scientific societies in the same country have also declared in favor of the same system. And what is perhaps still more significant, since in processes of manufacture involving the use of machinery changes in the measure of length are likely, if anywhere, to be inconvenient, the most eminent mechanical engineers in England are open advocates of the substitution of the meter for the British yard. In the United States, because of our wide separation from the metric nations with whom our business relations are most intimate, our people do not individually feel, at least to any great degree, the embarrassment which arises from having daily to deal with discordant measures of quantity and value; yet our foreign commerce is greatly hampered by delays in the custom-houses, and by the increased labor imposed upon importers and upon the collectors of the revenues, resulting from this cause. When Great Britain shall have adopted the metric system — an event which cannot be very distant — the disadvantage of continuing to be the only important commercial nation maintaining a metrological system out of harmony with the rest, will be felt by our people so sensibly as to impel them, without doubt, to follow her example without much delay. The objects for which the international metric commission was assembled were, therefore, of hardly less interest to the non-metric nations than to those by which the meter has been already received, since this dimension represents to them their own probable future standard of length. But the enlarged and liberal view taken by the commission of its proper functions, after it had been assembled, was such as to make this interest not merely, as here indicated, prospective, but direct and immediate. The attention of the commission was, in the first instance, naturally occupied with the object of replacing the platinum meter-bar of the archives, which is liable to the objection that it is the national standard of France, by a new prototype, identical with that in length, to be the common standard of the metric nations, and ultimately the common property of all mankind. This plan having been matured, and

provision made for the careful preservation of the prototype, and for the multiplication of authentic copies of the same, to be distributed among the nations, and made the local standards of measure in different parts of the world, the commission proposed greatly to enlarge the usefulness of the permanent organization to which these tasks should be committed, by charging it with the duty of comparing and verifying all standards of precision, of whatever kind, in measure or weight, which may be sent to it for that purpose, whether by governments or by scientific organizations, or by individual investigators or artisans. By this means the relation of the national standards of non-metric nations to the base of the metric system and to each other will be determined with the highest degree of accuracy, and the great works of geodesy, which have been founded on different units of measure, will become strictly comparable. The directors of such great works, the ordnance survey of Great Britain, for example, and our own coast survey, have, from time to time, expended a vast amount of labor in making these determinations, — determinations which are greatly exhaustive of time, and of which the results are still, to some degree, discordant, and are not wholly satisfactory. It will be in the power of the international bureau to prosecute these comparisons under circumstances of advantage which have not been hitherto enjoyed, and to follow them out persistently until uncertainty shall no longer be felt to affect the results. The proposition also to verify the scales or standards of measurement presented by investigators or citizens, scales designed to be used in experimental inquiries, will give a new degree of precision to the results of observation, and make it possible to combine the observations of different observers with a degree of confidence which it is not now possible to feel.

It appears, therefore, to the undersigned, that the creation of an international bureau for the objects set forth in the proposition of the International Metric Commission, cannot but be attended with important advantages, both practical and scientific, to all nations which shall unite in maintaining such an institution. Subject as the proposed bureau will be to the control and direction of a permanent committee, of which no two members will be appointed from the same nation, it seems impossible that it can be perverted from its original design to subserve any secondary interest. On the other hand, the concurrence of the nations in a common effort to promote an object pacific in its nature, and peculiarly characteristic of an advanced civilization — an object which, while it concerns directly the material welfare, concerns at the same time, indirectly and to an important degree, the intellectual progress of the human race — cannot but be regarded with gratification for its own sake by every friend of humanity, as evincing some slight recognition of the principle of the solidarity of peoples, — a principle which, in the coming centuries, is unquestionably destined to ameliorate the condition of the world.

The undersigned, therefore, concur in recommending that the Secretary of

the Treasury be advised that, in the view of the National Academy of Sciences, the government of the United States would not act unwisely in entering into a treaty stipulation with the government of France to lend the aid of this government in the creation and maintenance of the proposed International Bureau of Weights and Measures.

All of which is respectfully submitted.

F. A. P. BARNARD, *Chairman.* STEPHEN ALEXANDER,
H. A. NEWTON, J. PETER LESLEY,
M. C. MEIGS, J. E. HILGARD,
WOLCOTT GIBBS, JOSEPH HENRY.

At a meeting held in April, 1875, during the session of the diplomatic conference above referred to, the Academy manifested still further its interest in the important negotiation then pending, by the adoption of the following resolutions: —

Resolved, That, in the opinion of the National Academy of Sciences, an International Bureau of Weights and Measures is an instrumentality practically indispensable for the complete and satisfactory accomplishment of the important objects for which the International Commission of 1870 and 1872 was convened, viz., the perpetuation unaltered forever of the basic units of the metric system of weights and measures; the construction, verification, and distribution to the different nations of authenticated copies of the prototype standards representing these units; the recomparison of such copies hereafter, and the construction and verification of new copies for the use of scientific bodies, and of other organizations and individuals engaged in the conduct of important public works, or in the grand operations of international commerce; and finally, for the preservation and proper care of the valuable apparatus and instruments employed in such constructions and comparisons.

Resolved, That it is eminently desirable that our country should participate in the honor of maintaining an institution destined to exercise hereafter an influence so beneficial to the material interests of the human race, by securing that exactness in the determination of quantities which is so essential to the success of human calculations and that precision in the results of scientific investigation without which progress beyond a certain rudely defined limit is impossible; and that the President of the United States be accordingly respectfully solicited to ratify the assent which is understood to have been provisionally given by his diplomatic representative in Paris to the creation of such a bureau, and to recommend to Congress to make the necessary provision to defray such portion of the expense attending its maintenance as may probably fall to our share.

Resolved, That a copy of these resolutions, authenticated by the signature of the proper officers of the Academy, be forwarded by the President of the Academy to the President of the United States.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

This large and influential organization held its first meeting for scientific purposes in September, 1848, in the city of Philadelphia. At a very early period of its history (1849) it appointed a committee charged with the duty of reporting on uniform standards of weight, measure, and coinage, of which the late distinguished Secretary of the Smithsonian Institution, Prof. Joseph Henry, was the original chairman. At the meeting of 1850, held at Charleston, the chairman reported that a circular had been prepared and addressed to a large number of eminent scientific gentlemen throughout the country, soliciting from them suggestions as to the principles which should govern the construction of a system of metrology most advantageous for scientific and practical purposes; and that the committee would not be prepared to report until they should have more maturely considered the subject referred to them, and should have had time to compare and digest the responses they hoped to receive.

No further mention appears to have been made of the subject in the successive annual meetings until 1855, when the Association explicitly committed itself in favor of the decimal system by the adoption of the following resolutions, instructing their committee, among other things, to prepare and present to Congress a memorial praying for the adoption of such a system in the United States: —

Resolved, That the Committee on Standard Weights, Measures, and Coinage be authorized to correspond with other associations or public bodies, or with individuals, in regard to the establishment of universal and permanent uniformity in weights, measures, and coinage, and be requested to report at the next meeting.

Resolved, That the Committee on Weights and Measures be instructed to correspond with Great Britain and France, and such other countries as may seem desirable, on the subject of coinage, and to present a memorial to Congress, at its next session, in favor of the adoption of the decimal system of weights and measures.

The report called for in the first of these resolutions appears never to have been made; but the memorial to Congress required by the second was duly prepared and presented. In 1860, at the

meeting held in Newport, R.I., the committee presented a brief report, suggested by certain "movements recently made in these subjects," but which contained nothing of sufficient interest to be cited here, except an incidental discussion of the principles of "a very remarkable report on weights and measures, presented to the American Pharmaceutical Association, by Alfred B. Taylor, Esq., of Philadelphia," in the course of which the committee very distinctly manifest their preference for the decimal ratios in opposition to Mr. Taylor, whose proposed system is octonary.

At the same meeting the following resolution was adopted: —

Resolved, That the Committee on Weights, Measures, and Coinage are authorized to correspond with such departments of the government of the United States, with the commissioners to the Statistical Congress, and such other persons at home and abroad as they may deem expedient, to obtain information to be laid before this Association in furtherance of the objects of their appointment.

Unfortunately, during the six years next succeeding this action, the meetings of this Association were altogether suspended, the membership having been derived indiscriminately from all the States of the Union, and an unhappy civil strife having drawn between the North and the South a temporary line of fire. The meeting for 1861 had, moreover, been appointed to be held at Nashville, Tennessee, in the month of April; but such was the sombre aspect of public affairs in the opening of the year, that the executive committee deemed it advisable to issue a circular postponing the meeting, at first to a later day, and afterwards indefinitely. It was not until the spring of 1866 that the time seemed to have arrived when an attempt might be judiciously made to revive the Association so long dormant and seemingly disintegrated. In that year, a circular addressed by a majority of the members of the executive committee to such of the former members as could be reached, inviting them to attend a reunion to be held at Buffalo, N.Y., in the month of August next ensuing, met with an unexpectedly cordial response; and a meeting held in accordance with this invitation, under the officers elected six years before at Newport, was entirely successful.

At the meeting of the following year, held at Burlington, Vt.,

the following resolutions, presented by Professor (afterwards President) Caswell, of Brown University, were referred to the Committee on Weights and Measures, and by that committee favorably reported, and adopted by the Association: —

Resolved, That the Association reaffirms its earnest and cordial sympathy with legislation tending to the adoption, as soon as may be practicable, of the metrical system of weights and measures.

Resolved, That, whereas the gold dollar of the United States bears, practically, a simpler relation to the metrical system of weights than the gold monetary unit of any other country; *and whereas*, the present dollar is the unit more extensively used among commercial nations than any other; therefore, in the opinion of this Association, it is inexpedient to disturb or change, without the most careful and cautious consideration, either the weight or fineness of the existing monetary unit of the United States, viz., the gold dollar.

Resolved, That copies of these resolutions be forwarded by the Permanent Secretary of this Association to the Secretary of the Treasury, to the Chairman of the Committee of Finance of the U.S. Senate, and to the Chairman of the Committee of Ways and Means of the U.S. House of Representatives.

At the meeting of 1869, held at Salem, Massachusetts, the gold dollar was again the subject of a resolution reported by the Committee on Weights, Measures, and Coinage, in which, proceeding a step further than before, the committee proposed to make the weight of this coin absolutely metric. The resolution, which was adopted, was in these words: —

Resolved, That this Association cordially approves the proposed adaptation of American coinage to the metric system by making the value of the gold dollar precisely that of one and a half grams of fine gold, seeing in this a new step toward the promotion of fraternity among nations by the unification of weights, measures, and coinage, inasmuch as all monetary units which have simple relations to the gram must have simple relations to each other.

After the conclusion of the Convention of 1875, providing for the creation of an International Bureau of Weights and Measures, and in anticipation of the submission of that convention by the President to the Senate of the United States for ratification, the Committee on Weights and Measures laid before the Association, at the meeting held in that year at Detroit, Michigan, a

report of some length, reciting in full detail the history of that negotiation, and concluding with resolutions earnestly recommending the ratification of the treaty in question. As the facts and considerations embraced in this report have been fully exhibited in section third of this supplement, or in the report of the Academy of Sciences on the same subject given above, its insertion here is unnecessary. The accompanying resolutions, however, with their preamble, deserve a place in this narrative, and they are accordingly here reproduced. They are as follows: —

Whereas, In the investigation of science, precision in the determination of quantities is essential to the discovery of truth, and therefore every measure which has for its object to secure or maintain accuracy in the standards of measurement is directly promotive of scientific advancement, and is of interest to every investigator; and

Whereas, It has been made known to this Association that a convention was entered into early in the present year by the leading powers of the civilized world, through their diplomatic representatives, providing for the creation and maintenance in the city of Paris of an organization to be called, "The International Bureau of Weights and Measures," for the preparation, verification, and distribution to the governments of all the assenting powers, of accurate standards of measurement, and for the preservation, unaltered forever, of the prototypes from which such standards are derived, to which convention the government of the United States became a party by the assent of the President and the signature of its authorized representative; and

Whereas, For the purpose of defraying the cost of the necessary buildings and equipment, and for the maintenance of such Bureau in the discharge of its proposed functions, it is provided in the said convention that each of the high contracting powers shall contribute according to a scale dependent on its population and its relation to the metric system; the amount of such contribution being in every case inconsiderable and entirely insignificant in comparison with the advantages to be derived; therefore,

Resolved, That a memorial address to the Congress of the United States on behalf of this Association be prepared for signature at this present meeting, praying the Senate to confirm the action of the Executive Department, and praying Congress to make early provision to discharge the obligations resting upon us in consequence of the stipulation of the International Convention above mentioned distributing the burden of expense attendant on the creation of the International Bureau of Weights and Measures and on its subsequent maintenance among the signatory powers; and that the said memorial be signed, not only by the members of this Association here present, but also by such of those not in attendance as may choose to attach their signatures, to the end that the prayer of the memorial may be made, if possible, unanimous.

Resolved, further, That such memorial, when so signed, be transmitted in duplicate to the presiding officers of the Senate and House of Representatives by the President of the Association, immediately on the assembling of the forty-fourth Congress in December next.

In pursuance of this action, the following memorial was drafted and numerously signed before the adjournment of the Association.

To the Senate and House of Representatives of the United States in Congress assembled: —

The undersigned, members of the American Association for the Advancement of Science, having learned with great satisfaction that a convention has been entered into by the leading nations of the world for the establishment and maintenance of an International Bureau of weights and measures, with the object of promoting permanence, precision, and uniformity in the standards at the joint charge of the contracting powers; and that the government of the United States has agreed to the same through its diplomatic representative, subject to the ratification of the Senate; do now, for the considerations set forth in the accompanying report and resolutions, respectfully urge that the Senate, without delay, ratify said convention, and that Congress make the requisite appropriation to carry the same into effect.

The meeting of the Association for 1876 took place in the month of August, the first protracted session of the Forty-fourth Congress having in the meantime, to the grievous disappointment of the friends of this important measure, come to a close without any favorable action upon the convention, which had been submitted to the Senate some months before, and even without any action at all. The committee accordingly felt bound to draw the attention of the Association to the subject once more, and to urge upon the members the necessity of more general and active effort with a view to impress public opinion in its favor; not because our coöperation was any longer essential to the success of the International Bureau, but because the success of that institution without our coöperation would be an ineffaceable discredit to ourselves. It happened also that during the same period in which this question of purely metrological interest continued to be suspended in doubt, another question of much graver and more exciting character affecting our system of money and coinage, and threatening to unsettle every principle of sound finance hitherto supposed to be established, was suddenly thrust forward into the

forefront of political controversy, and was made by all parties the occasion of a competitive struggle for the palm of violence. It seemed to the committee to be the duty of the Association, as in a sense representing the science of the country, to declare itself distinctly upon this vitally important question, — a question which properly belongs to the domain of science, and which should never be submitted to the arbitrament of a blind popular prejudice, or allowed to be made the foot-ball of designing demagogues. The committee, therefore, presented a report embracing both the topics above referred to, but devoted chiefly to the second, with the design that the voice of the Association, so far as it might be determined by them, should utter no uncertain sound. This report, which here immediately follows, is given without abridgment.

To the American Association for the Advancement of Science:—

In conformity with the design of its institution, which was to bring to the notice of the Association, from time to time, such subjects as seem to call for their action or the expression of their opinions, the Committee on Weights, Measures, and Coinage beg leave, first, to submit a statement of the progress made in the effort to secure the participation of the government of the United States in the establishment of an International Bureau of Weights and Measures; and secondly, to invite attention to certain questions of grave importance now agitating the public mind concerning the principles which should govern legislation in regard to standards of value, in the decision of which, in the view of the committee, are largely and directly involved the material interests and welfare of the people of the United States, and indirectly those of the whole civilized world.

First, as to the International Bureau of Weights and Measures. In the report of this committee presented to the Association at the annual meeting of 1875, held at Detroit, the fact of the then recent negotiation of an international convention, to which the Government of the United States had been an assenting party, for the establishment and permanent maintenance of an institution for the preparation and verification of standards of measurement, and the preservation, unaltered forever, of the prototypes from which

such standards are derived, was stated, accompanied by a resolution that a memorial to Congress be prepared for signature by members of the Association and others, praying the Senate to ratify the action of the Executive Department in entering into the convention, and praying Congress to make provision to discharge the obligations resting upon us in consequence of our adhesion to such convention, which resolution was unanimously adopted.

In compliance with the requisitions of this resolution, the proposed memorial to Congress was prepared without delay, and was circulated as widely as circumstances and the limitation of time would allow. The professional engagements and absorbing occupations of most of the members of the Committee prevented as extensive a personal canvass as could be desired; but it is highly gratifying to the Committee to be able to state that, in nearly every quarter in which the memorial was presented for signature, it met with cordial approval and was signed without hesitation.

As it seemed to be desirable that the presentation of the memorial to Congress should take place as early as possible after the opening of the session in December, the effort to obtain signatures was not persisted in later than that date. Up to that time, however, there had been obtained more than eleven hundred names, a number already large, in which, nevertheless, the individual weight is more strikingly significant than the aggregate total. Copies of the memorial with these signatures attached have been printed for distribution. It will be seen that among the signers twenty States are represented, and a large proportion of the names are easily recognizable as those of the most prominent and influential citizens of the communities to which they respectively belong. Especially noticeable is the fact that the educators of the country, whether engaged in literary, scientific, or professional institutions of learning, have largely contributed to swell this list. Among this class, the sentiment has been found to be almost universally one not merely of passive approval, but of lively interest in the object of the memorial. Next to this may be mentioned the engineers, architects, and leading manufacturers of our principal towns, men whose daily occupations impress them continually with the importance of exactness in the measurement of quantity, and with the necessity of accurate standards of weights and measures,

in order that such exactness may be secured. By examining the list of these names it will be perceived that this intelligent class of our fellow-citizens distinctly recognized the fact that the object of the International Bureau is one of far higher importance and dignity than that of promoting the advancement of any particular system of metrology, since there will be found among them the names of well-known men who have publicly expressed their unwillingness to see the metric system of weights and measures made compulsory in the United States.

Another class of great weight in the body politic represented in this list is made up of the bankers, merchants, and capitalists of our great commercial centres. These, in every instance in which the expression of their sympathy has been solicited, have, without hesitation, added their names to the memorial. The signatures of a single city belonging to this class represent an aggregate of more than a hundred millions of dollars.

It will thus be seen that among the signers of the memorial are represented largely both the intelligence and the wealth of the country. And the readiness with which these names have been given affords a convincing evidence that the sentiment of the classes to which they severally belong is everywhere, with a near approach to absolute unanimity, favorable to the objects of the memorial.

The ratification of the convention establishing the bureau, should it be ratified on the part of our government, will entail upon the United States a certain but quite insignificant expense, first as a contribution toward the creation and equipment of suitable buildings, and secondly as an annual subsidy for the permanent maintenance of the institution. The amount is too trivial to be for a moment considered, in view of the inappreciable importance of the object to be secured. But were it much greater, it is quite evident that the people, by whom this expense is to be ultimately borne, are entirely content, not to say desirous, to assume this inconsiderable burden.

On its presentation to Congress, the memorial of the Association was referred in the House of Representatives to the Committee on Appropriations, and in the Senate to that on Foreign Relations. In compliance with the invitation of this latter committee, certain

nembers of the committee of the Association appeared before hat body and made statements more fully explanatory of the nature and design of the proposed Bureau, the impression left being apparently favorable. The Senate committee, nevertheless, delayed its report on the subject, presumedly waiting for the action of the committee of the House on the question of appropriation, while the House seemed similarly to await the decision of the Senate on the question of ratification; and thus the session of Congress became at length so far advanced that it seemed inadvisable to urge a report liable to be exposed to the hazards of hasty nd inconsiderate action in the closing hours of a protracted session. By the advice of the friends of the measure in the committee of the Senate, therefore, the subject was permitted to lie ver until after the assembling of Congress in December next, hen it will come up among the unfinished business.

In the meantime, however, it is greatly to be desired that the nembers of the Association in all parts of the country should ring to bear all the means of influence which they possess to impress the popular mind with the importance of the proposed object, nd to secure the expression of popular opinion in regard to it, in nodes which may tend to promote its success. Much may be done this respect, after the excitement of the approaching or actual olitical struggle shall have passed away, and men's minds, ceasg to be occupied with matters of temporary concern, shall be pable of contemplating calmly those of more permanent intert, by a judicious use of the press. The conductors of our public urnals may be counted on, almost to a man, as favorable to the jects of the memorial, and many of them, if the subject is proply brought to their attention, will undoubtedly lend to the mease the support of their editorial columns. All will, without uestion, give publication to properly written communications garding it; and thus the friends of the measure may, by means a little effort, diffuse valuable information in quarters where it needed, and awaken an active interest in favor of the movent, where, for no reason but the lack of information, such interst has not hitherto been felt.

The assent of the government of the United States to the conention establishing the International Bureau of Weights and

Measures is not necessary to the existence of that institution. The International Bureau already exists. By the adhesion to the convention of the other signatory powers, it has been established on a permanent footing; and all the benefits to the world, to our own people among the rest, which it was designed, and which it is certain to secure, have been provided for beyond the possibility of failure. The only question for us now to settle is whether, in a measure which will be regarded by all future generations as one of the wisest ever adopted by the common consent of peoples, a measure which marks, perhaps, more signally than any other the advanced civilization of the nineteenth century, the people of the United States shall be participators or not. It is no longer a question of public economy or of public policy merely, which the fate of this measure before our Congress is to decide; it is rather a question of national character and of the repute we are to leave behind us for national enlightenment.

Since the presentation of the report of this committee made to the Association at the Detroit meeting, facts have been ascertained at the Bureau of Weights and Measures of the United States in Washington, which add materially to the weight of the considerations to which the project of the International Bureau was originally owing. It has become manifest that solid measures of length, heretofore prepared with the utmost care, and regarded as perfect and invariable, have undergone, after not a very extended period of years, changes sufficiently great to destroy their character as standards, and to render it necessary to resort to new and laborious comparisons to determine their errors. Concerning this matter, and others connected with this subject, the actual head of this Bureau, Mr. Hilgard, a member of this committee, will make a statement supplementary to this report, which will be found to possess a novel and very important interest.

The subject to which, in the second place, the committee feel it their duty to call the attention of the Association, is the confusion at present prevalent in the public mind in regard to the principles which should govern the creation by law of standards of value. In many instances the opinions professed on this subject appear to have been formed on the basis of a belief that, being popular, they may be made instrumental in securing some partisan political

advantage; and not from any profound study of the principles which must control the results of the policy adopted, and which, being inexorably fixed in the nature of things, no legislation can successfully set at defiance. With the partisan aspects of the subject this committee have nothing to do. They can only deplore that, in a matter so vitally important to the prosperity of communities or individuals, any consideration of momentary interest should be powerful enough to obscure truth, or to predispose men to receive the truth unwillingly.

Money was originally introduced to facilitate the transactions of commerce. Commerce may be comprehensively defined as the exchange of equivalent values. In its earliest stages, commerce took the form of barter. In this form it was embarrassed by the infrequency with which individuals desirous of effecting exchanges found themselves in possession of commodities reciprocally acceptable. In order to remove this embarrassment, the expedient was devised of employing a material of well-known and universally recognized value to serve as a medium of exchanges, and as a measure of the value of all exchangeable commodities. Such a material was found in the precious metals, and hence, from a very early antiquity, gold and silver have constituted the medium of commercial exchanges among all nations. From the nature of the exigency which called it into existence, and from that of the function which it continues to fulfil, it follows that money, in order to be capable of serving as a means of exchanging values, must possess a positive value itself. On no other supposition can it properly be called a standard of value. The term *standard* implies comparison, and there can be no comparison between objects which do not possess a common quality. It is usual to apply the term *money* to the promissory notes of banking institutions, or to those of the government; but this is a perversion of language, since such notes are not money but only the representatives of money, and they are accepted as the equivalents of money only on the faith that the money they represent shall itself be forthcoming whenever demanded. When such conversion is not promptly possible, or when the period at which it may be effected is remote or doubtful, these bills of credit will only be receivable in commercial transactions at a discount which is understood to measure

the disadvantage of the delay or the hazard implied in the doubt. There is no power in legislation to make the promise of a dollar the equivalent of a dollar, so long as such promise is not invariably fulfilled on demand, or so long as the time or the fact of the fulfilment remains in the slightest degree uncertain. The law which makes the greenback notes of the government a legal tender in all payments except those of the customs-duties, fails signally to accomplish its object; and it has done so in degrees varying between very wide limits, for the past twelve or fourteen years. This law enacts that the government promise to pay a dollar shall be a legal tender for the value of a dollar. But as the value of a dollar is only ascertainable by reference to the law creating the coin of that name, and as such a coin will purchase in any market a larger amount of any commodity than its legal tender representative, it is obvious that, while the letter of the law is observed, its intent is effectually evaded. The seller who has commodities to dispose of, indemnifies himself for the depreciation of the currency by marking up his prices. A standard of value must therefore be intrinsically valuable. A perfect standard, if such an one could be found, should not only be intrinsically valuable, but invariable in value through successive years or centuries. And the usefulness of any medium of exchanges will be greater, in proportion as it is capable of representing a larger value under a given bulk or weight. No substance has been found possessing the desirable property of a value absolutely invariable. This property, however, belongs to the precious metals in so high a degree as to have secured for them the preference over all other substances for the purposes of money. Their variations of value have hitherto been so inconsiderable and so slow as to have produced no perceptible effect upon the transactions of business. But the fact that these slight changes have not usually been in the same direction for both metals simultaneously, and that, consequently, the relative as well as the absolute value of the two have been subject to gradual fluctuations, has introduced frequent and sometimes serious disturbances into the monetary systems of those nations in which both have been made by law equally standards of value and the material of coinage legal tender for all amounts.

A coinage founded on what is called a double standard must

necessarily assume a fixed relation of value between the two standard metals, weight for weight, or a definite relation of weight, value for value. This relation is naturally determined by the ruling ratio at which the metals, in the form of bullion, may be purchased in the market at the time of institution of the system. So long as these rates remain unaltered, the coins struck from both metals circulate with equal freedom, and no pecuniary advantage can be gained by the payment of a debt in one description of these coins rather than in the other. But this condition of things is never lasting. Every variation of the market rates introduces a new relation of actual value between the metals, and, generally, a relation differing from that established by law; so that it will be found almost invariably that, at any given time, a given gold coin will purchase more or less silver than the amount of that metal contained in the silver coins which are at the same time its legal equivalents. If it will purchase more, then the coin-silver is overvalued, and it will be a paying transaction to exchange silver coins for gold, and to export the latter or melt them up and sell them as bullion. If it will purchase less, the coin-silver is undervalued, and it will pay to reverse the operation just described, and buy up, for the purpose of melting or export, silver coins with gold.

As in this state of things the debtor will always elect to satisfy his obligations in the coinage of the relatively cheaper metal, it follows that wherever a double standard exists in law, a single standard inevitably rules in point of fact; and this ruling standard is that of the metal in which the coins of a given name represent the smallest actual value. The consequence is that the coins of the undervalued metal disappear; nor can any activity of the mints maintain them in circulation; since being at a premium with the practical standard, they are, to all intents and purposes, demonetized and converted into bullion. Thus the effect of a double standard is, singularly enough, to limit the coinage of the nation adopting it to a single metal. This may not, it is true, be always the same metal; for, in the gradual fluctuations which are continually going on in the relations of value between gold and silver, it may happen that either of these metals may be alternately at a premium when compared with the other as a standard. In the experience of the world, hitherto, such alternations have not often

occurred except after considerable intervals of time. In case of such an occurrence, it of course happens that, during the period of transition, there is a moment in which the double standard is a reality; but this condition has the character of an unstable equilibrium which cannot endure. Ordinarily, governments have not waited for the turning of the scale through the operation of natural causes. In innumerable instances the attempt has been made to restore the lost equilibrium by altering the relations of weight between the coins of the different metals; and in making these alterations it has been unfortunately true that the more valuable coin has invariably been reduced in weight, and not that the less valuable has been increased. An illustration of this tendency in the history of our coinage may not be beyond the recollection of some of the members of this Association. Early in this century, and down to the year 1834, a gold coin of the United States was an object rarely seen; so rarely, indeed, that collectors sometimes treasured up those coins in their cabinets as curiosities. This was in consequence of the coinage act of 1792, which fixed the relative values of the two metals in the ratio of one to fifteen. These numbers express a relation which may have been approximately true at the date of the act, but very shortly ceased to be so, the market ratio between the metals becoming soon after more nearly one to fifteen and a half. In this state of things, gold coins legally representing the nominal value of fifteen dollars melted down into bullion, would sell in the market for fifteen and a half legal tender silver dollars, and gold totally vanished from our circulation. At length, in the year above referred to, 1834, Congress undertook to restore the disturbed equilibrium, and this object it accomplished, not by raising the value of the silver coins, but by depressing that of the gold. The weight of these was reduced so as to make it almost exactly one-sixteenth that of the legally equivalent coins of the less valuable metal. The object, as just observed, was accomplished. In point of fact, it was somewhat more than accomplished, for the effect of the new statute which brought gold into circulation, was, at the same time, to some extent to undervalue silver. Silver coin, therefore, ceased, in turn, to circulate, except in the form of fractional currency.

In France the legal relation of value between gold and silver

has been, ever since the establishment of the metric coinage, as one to fifteen and a half. The market ratio has fluctuated in the meantime (down to 1876), between the limits, one to fifteen and one to sixteen, without ever quite reaching either. The consequence has been that both metals have been alternately at a premium when either is compared with the other. From about 1852 to 1870 the market ratio was about one to fifteen and three-eighths. Silver, accordingly, almost ceased to circulate. More recently the ratio has passed the point of equilibrium, and the balance has turned the other way; there is a tendency of silver to circulate to the exclusion of gold. But this tendency has been wisely counteracted by the government of that country, partly by retiring the silver and partly by putting a limitation on the amount of the future coinage.

Examples of this description might be multiplied almost indefinitely. They serve as practical illustrations of the truth, already sufficiently evident from abstract considerations, that the notion of a double standard in coinage is a fallacy which experience most inevitably contradicts; that, practically, at any given time, a single standard of value is only possible, and that, wherever, in the contemplation of law, there are two such standards in existence, the actual standard will always be that which is furnished by the metal most cheaply purchasable in the market. It is further apparent that wherever, as in France from 1852 to 1870, and in the United States during the forty years from 1834 to 1874, silver is the metal which is undervalued, it will be found practically impossible, on the double standard system, to maintain in circulation a sufficient amount of coin of small denominations to subserve the every-day wants of society in the petty transactions of trade. This difficulty can only be effectually overcome by creating a silver coinage legal tender only for limited amounts, in which the weight of metal shall be so reduced as to make its market value less than its legal. Such a coinage may ideally coexist with another of the same metal having the full proportion of weight required by law to make it legal tender for all amounts; although this latter, in consequence of undervaluation, is practically excluded from circulation. Such a condition of things was created in France, Belgium, Switzerland, and Italy by the quadripartite treaty entered into between those

powers in December, 1864, by which provision was made for the issue of silver coins below the denomination of five francs, of debased standard, and legal tender only to the amount of fifty francs, while the outstanding silver coins of full standard continued to be legal tender for all amounts. Such also was the case in the United States from 1853 to 1874, during which period the silver dollar continued to be legal tender for all amounts, while the smaller coins were degraded in weight, and were, as they still continue to be, legal tender only to the value of five dollars. From 1843 to 1873 the silver dollar was coined in our mints only in small quantities, and was rarely seen in circulation. In the year last named its further coinage was prohibited, and in the revision of the statutes, completed during the following year, the dollars still outstanding were deprived of their legal tender character, except to the same extent as the minor coins of the same metal.

This plan of providing a subsidiary silver coinage to subserve the minor transactions of daily commerce was first introduced in the year 1816 in Great Britain, and since that time has been extensively adopted on the continent of Europe as well as in our own country.

From what has been said, it may fairly be inferred that the principle of a double standard of value in monetary systems is objectionable, both because it is practically fallacious, and because its inevitable tendency is to degrade the value of the coinage in the countries, in which it prevails. These truths have in recent years been so generally recognized by the ablest financiers of all countries that in every one of the now somewhat numerous international conferences which have been called to consider questions relating to coinage within the last quarter of a century; there has been a decided expression of opinion in favor of a single standard, and of adopting gold to serve as that standard universally. Already in many countries large steps have been taken toward the realization of this result. In some, in which the silver standard has not been absolutely abolished, it has been practically so by the introduction of a subsidiary coinage, and by stringent limitations upon the further coinage of legal tender silver. This is true of Germany, Holland, and the Scandinavian countries, and also of the parties to the quadripartite treaty of 1864. France,

indeed, though naturally clinging to the silver standard, in consequence of having originally connected her monetary system with her system of weights and measures by making the legal tender silver franc her money unit and giving to it a metric weight, went so far, through her commissioners to the monetary conference held in 1869 at the Hague, as to signify her willingness to adhere to the gold standard exclusively, provided the other nations represented would adopt as their unit the weight of the five franc piece of gold.

Within the past year or two there has been a very large and hitherto wholly unprecedented fluctuation in the market price of silver. This price has varied, within a period of a few months, through a range of not less than twenty per cent. of its original value. From its lowest depression it has partially recovered, and it now stands about midway between the extreme limits of its variation. The causes of this singular phenomenon have been variously assigned. It is not necessary to speculate on them here. But the fact of its occurrence, and the uncertainty how long this instability is to continue, are considerations which must be duly weighed when the proposition is presented to us to restore this metal to the place in our momentary system from which it has been deliberately, and for good reason, by law excluded. No quality is more absolutely indispensable in a standard than stability of value. It is to the possession of this quality in an eminent degree during the past centuries, that silver has owed the place it has so long occupied in the monetary systems of the world. With the loss of this quality, it has lost its claim any longer to hold that place; and to make it once more, until at least the lapse of a long period of years shall have shown (what is very improbable) that the present disturbance is but a momentary accident not likely to be repeated, the material of coinage legal tender for all amounts, would be to disconcert all the calculations of commerce, derange all the operations of business, and entail upon the country widespread disaster reaching every class of society.

The committee have no design to exhaust the argument upon the subject under consideration. That would require an examination of the causes which have operated to affect the price of silver, the probability of their permanence, and the degree to which their

action in the future is likely to be regular or irregular. To pursue these inquiries would be to distract attention from the single point to which it is the desire of the committee to draw the attention of the Association at the present time. They reserve to themselves the privilege of going more fully into the subject at a future meeting, should not the questions which it involves, so deeply concerning the credit of the government and the general welfare of the people, be in the meantime satisfactorily disposed of.

One point, however, connected with this last aspect of the subject, should not be overlooked even in this cursory view. It has been said above that the discount on bills of credit, the liquidation of which is distant or doubtful, measures the inconvenience of the delay, or the hazard of the ultimate loss. If such a bill were immediately convertible into the coin it promises, there would be no discount. It would be accepted in business transactions for precisely that amount of coin; and, because of its greater portability, would in general be preferred to coin. The greenback bills of credit of the Government, if now redeemable on demand, would be worth one hundred cents to the dollar. The uncertainty in the centres of commerce as to the time when they shall be redeemed, or as to the question whether they shall ever be redeemed at all, is represented at present by a fluctuating discount of from ten to twelve per cent.; so that the greenback dollar is only accepted in the affairs of commerce for an amount varying from eighty-eight to ninety cents. Should the silver dollar of 412½ grains of standard metal be made legal tender for all amounts, its value at present would be about the same as that of the greenback dollar at present — say ninety cents — also. Then, if the greenback should be made immediately redeemable, its purchasing power would remain unaltered, or it would continue to be worth in the market ninety cents. But if it should not be immediately redeemable — if it should continue to be subject to the same uncertainty as at present in regard to the time of its redemption or the question of its ultimate redemption at all, its purchasing power would fall below that of the silver dollar, by as large a percentage as it is now below that of the gold dollar; and it would actually be worth as money only from about seventy-eight to eighty cents. Moreover, should silver, in the continual oscilla-

tions of its value, touch once more the point it reached no longer ago than July last, the silver dollar would itself be worth but eighty cents, and the greenback dollar would fall to seventy.

The effect of this sudden degradation in the value of the only currency available to our people at the present time, upon the immediate means of subsistence of all who labor for wages, or are dependent on fixed salaries for support, need hardly be pointed out. The income of every such person would be reduced by an amount which, should silver again descend to and remain at the minimum level of the past summer, may be as great as twenty per cent., and which certainly, should it continue at its present price, must be not less than ten. On the other hand the holders of merchandise of every description, including the necessary supplies of life, in order to protect themselves against loss, must raise their prices; and this, in view of the instability of the standard, and the hazard attending possible change, they would be likely to do in a greater proportion than that in which the currency is degraded; so that every man in the country who depends upon a fixed income would find himself doubly straitened — by the diminution of his resources on the one hand, and by the disproportionate increase in the cost of all the necessaries of life on the other.

In conclusion, the Committee would only add, that the existence of a double standard in coinage, at any time and anywhere, has been a consequence of a provision of nature quite accidental, according to which two metals, and only two, possess the properties which fit them, or have heretofore fitted them, both to be standards of value. Had there been three or four or five metals possessing equally the same properties, there would, beyond question, have been a triple, a quadruple, or a quintuple standard. But, in the state of things which would have existed on such a supposition, the evils consequent on employing more standards than one would, unquestionably, have been recognized at a much earlier period in the history of the human race than they have been in fact, and the nineteenth century would not have been vexed with the questions on this subject which keep the thinking men of our country in a state of so constant anxiety to-day.

With these remarks the undersigned respectfully submit the pre-

amble and resolution appended to this report, and ask for them the favorable consideration of the Association.

F. A. P. BARNARD, *Chairman*,

JOSEPH HENRY,	E. B. ELLIOTT,
J. E. HILGARD,	H. A. NEWTON,
WILLIAM B. ROGERS,	J. LAWRENCE SMITH.

PREAMBLE AND RESOLUTION.

Whereas, Gold and silver, like other gifts of nature or products of human industry, are subject to gradual changes of value; and no relation of values which may be by law established between them can permanently conform to the actual relation existing in the markets of the world; and

Whereas, Coins of these two metals cannot for any length of time be maintained in circulation side by side, when the coinage of both is equally free from limitation, and both are made legal tender in payment for all amounts; and

Whereas, It is historically true that legislation, in the endeavor to restore the disturbed equilibrium between the standard metals, has tended invariably to depress the grade of the coinage in one or the other and ultimately in both; and

Whereas, It is the aim of enlightened governments everywhere at the present day, whether by the absolute abolition of the double standard or not, to make gold for all practical purposes the single standard, and to employ silver chiefly or wholly as the material of a subsidiary coinage, legal tender only to limited amounts; and

Whereas, The United States, after an experience of nearly a century in the effort to maintain a double standard, during the earlier portion of which, under the operation of the inexorable laws governing exchanges, gold was completely banished from circulation, while during the later, silver of legal tender grade has shared the same fate; and after the complete disappearance of the silver dollar from business transactions for more than forty years; have at length, by an act of deliberate and wise legislation, extricated the country from this long-standing evil and have adopted gold as the sole standard of value in their monetary system; therefore,

Resolved, As the sense of this Association, that the single standard of value in our system of coinage, now fully established by law, ought to be maintained, and that every proposition to restore to silver the legal tender character for payments to all amounts ought to be discouraged.

The report was received and referred to the Standing Committee. At the next succeeding meeting in general session, the report and its accompanying preamble and resolution were adopted as expressive of the sense of the Association.

Other Societies. — The liberal space which has been given to the two Associations whose acts and proceedings as to matters of metrological interest have been detailed above, is justified by the large relations which those Associations sustain to science in general, and to the fact that, geographically considered, they represent the entire country. If the attempt were made to follow with equal particularity the proceedings of the various local organizations of a scientific or a professional character which have interested themselves in the same subject, it would probably fail for lack in many instances of the necessary information; or, if successful, would swell this work beyond reasonable limits. Many such associations have borne their testimony in favor of the metric system, either by resolution or in the form of reports of committees accepted and approved. Some have declared themselves in favor of the early introduction of the system into general use; and some have gone so far as to petition Congress to pass an act naming a day in the not distant future, from and after which it shall not be legal to employ any other system of weights and measures but the metric, in business contracts in this country. A few, not limiting themselves to the public expression of their own views, have sought, by correspondence and by gathering and diffusing information on the subject, to operate upon public opinion, and to stir up others to similar action.

In efforts of this nature the Boston Society of Civil Engineers has been especially distinguished. At a meeting of this society, held in November, 1875, there was appointed a standing committee on the metric system, charged generally with the duty of collecting facts and making suggestions in respect to the introduction of the metric weights and measures into use, and instructed particularly to open communications with other organized bodies, with the view to bring to bear upon Congress a concerted pressure from as many and as various directions as possible, urging active measures of legislation in favor of the

desired object. The first annual report of this committee, published in December, 1876, presents an interesting and valuable record of the results of energetic and faithful work done during the year. It enumerates a variety of facts ascertained in regard to the progress made in the actual introduction and use, without waiting for acts of compulsory legislation, of metric weights and measures by business houses and professional men in this country — a progress which is continually gaining ground at a rate which, if it continues, is likely in time to supersede the necessity of legislation; and it gives a synopsis of the replies received from a considerable number of Associations in different parts of the country to which the circular letters of the committee had been addressed. Among the encouraging facts mentioned are the adoption of the metric measures to the exclusion of all others in the extensive works of the celebrated Waltham Watch Company, and in those also of the American Watch Tool Company, of the same place. It is remarked, in regard to these, that the change from the measures previously in use to the metric was made without any serious difficulty, embarrassment, or material expense, by merely substituting tools adapted to the new system, in place of old ones as they were worn out.

From the Pratt & Whitney Machine Company, of Hartford, Conn., is given an extract from a letter, expressing the opinion that this method of change by gradual substitution is one which is entirely practicable in all departments of manufacture; and one which, if adopted, would permit the change to be accomplished "with little loss, and with not much more trouble than is now experienced from variations in measures."

The report speaks also of the evidences which presented themselves at the Centennial Exposition in Philadelphia of the growing tendency to employ the metric measures. The large drawings representing the engineering work at the great Hoosac Tunnel in Massachusetts were constructed to a metric scale; metric charts and diagrams appeared in the educational department; car-wheels were exhibited adapted to the metric gauge of East Indian and South American railways; metric standards were displayed from the United States Bureau of Weights and Measures; and the balances of the Fairbanks Company weighed visitors in kilograms

as well as in pounds, and distributed cards showing the difference between the old tables and the new.

The report further remarks that the growing popularity of the system is attested by its frequent use or mention in periodical publications; a fact which is not true merely of periodicals devoted to science or to scientific professions, but more or less of such as are purely literary in their character. Thus, "Scribner's Monthly Magazine," which is said to have a circulation of eighty thousand copies, employs habitually the metric denominations in expressing quantities. And in illustration of the degree to which the subject is attracting and occupying the public attention, it is amusingly added, "Indeed, so prominent is the theme, that we are told the 'Congregationalist' opposes the metric system, because it does not want to have the revised edition of the New Testament read, 'Neither do men light a candle and put it under a hectoliter.'"

It was one of the duties imposed on this committee to draw up a memorial to be presented to Congress. In discharging this duty the committee frankly confess that they have little hope from any legislation which is not of a radical character. They express the opinion that it is idle to expect people to put themselves to expense or inconvenience in making changes in their own practice, to which others are not disposed, and cannot be constrained, to conform; and, therefore, in their view, the transformation can make no important practical advance in this country, "until Congress shall have taken such action as shall convince people that the reform is inevitable, and as will enable them to foresee at about what date it will probably be accomplished." It is for this reason that they resolve to ask of Congress, plainly and boldly, to take precisely such action. They say, "We propose to let Congress decide *when* to take that action; but we mean to have it understood that *we* are ready for it *now;* and we wish all of our fellow-citizens, who are of the same mind, would say so too."

The memorial prepared by the committee, therefore, for the signatures of the members of the society, expressed this readiness and this desire; and added that the signers "would welcome legislation which should result in a harmonious movement among all the people, every one knowing when to take the successive steps of change, and confidently relying upon the action of others at a

time to combine economically with his own efforts;" ending, finally, with the prayer that the honorable body addressed "may enact that, after some date to be fixed several years in advance, the metric standards in the Office of Weights and Measures at Washington shall be the sole authorized public standards of weights and measures." The memorial conceived in these terms received the approval of the society, and was duly signed, transmitted to Washington, and laid before the Forty-fourth Congress.

In the correspondence which the committee were instructed to institute with other organizations, it was a prominent object to secure the concurrence of those other bodies in this endeavor to impress the national legislature. Those associations were accordingly invited to unite in memorializing Congress in the identical language employed by the Boston society; and in many instances, though not in all, the solicitation was successful. At the date of the report, the circular of the committee had elicited responses from twenty-nine different bodies, of which, according to the classification of the committee, sixteen were favorable, five unfavorable, and eight undecided. This classification is, however, faulty, at least so far as the five styled unfavorable are concerned; for those of this class two, that is to say, of the American Metrological Society, and of the Philadelphia Board of Trade, are really favorable to the reform, although their authors doubt the expediency of demanding precipitate legislation. The first of the bodies here named was, as the account given in this supplement of its origin and object shows, instituted for no other purpose but to secure an improved metrological system; and by its whole course of action it has been committed to the metric system from the beginning. The second, even while declining to coöperate with the Boston Society in urging immediate legislation for the prospective compulsory introduction of the system, expresses "sympathy with the objects contemplated, but is not ready to indorse the system unreservedly by memorializing Congress for its adoption." A third, the College of Physicians of Philadelphia, merely evades a reply, by saying that it does not regard the subject in its present condition as coming within the province of the college. A fourth, the American Academy of Arts and Sciences, postponed the matter indefinitely by a vote of ten to eight. These last two should,

therefore, rather have been placed among the undecided than among those positively unfriendly. The fifth, however, the Franklin Institute of the State of Pennsylvania, must be set down as unequivocally and uncompromisingly hostile. Such, at least, is the temper of the Institute as determined by the majority of its members; notwithstanding the fact that among the minority are to be found some of the ablest and most earnest advocates of the metric system that the country possesses.

On the receipt by the Institute of the circular letter of the Boston Society, a committee, consisting of three members, viz., Messrs. Coleman Sellers, W. P. Tatham, and Robert Briggs, was appointed to consider and report upon this communication. Two reports were presented, one by the majority, consisting of the two members first above named, and the other by Mr. Briggs. The majority report was a labored and argumentative denunciation of the metric system, which was condemned upon its merits, and condemned moreover by a kind of imputation of guilt, as being somehow responsible for the crime and bloodshed of the period of violence during which it struggled into birth. The first count of this indictment is simply a reiteration of the objections to the metric system which have been so often stated before, and so often answered, that they have ceased to produce the slightest impression upon minds free from prejudice; objections such as the inconvenient length of the meter as an unit of linear measure; the importance of preserving harmonious relations between our own system and that of Great Britain; the immense expense which would be involved in the transformation of all our machinery and the change of all our tools to others of metric dimensions; the fact that the decimal ratios have not been (and the implied assertion that they cannot be) employed in the division of the circle; with others equally trite and equally void of force. The second count, by which the metric system is represented as the monstrous offspring of the Reign of Terror, from which good men should instinctively shrink, and which none can touch without contamination, is a charge so totally unfounded in the facts of history, that one is at a loss to understand how it can ever have found a lodgment in the brain of any tolerably well-read man.

A good deal of this kind of writing is no doubt traceable to the

influence of a class of visionaries, who, during the past fifteen or twenty years have contrived to create and maintain in the public mind a sort of amused interest in their fantasies, by certain extravagant speculations on the presumedly mystic structural features of the Great Pyramid of Gizeh, and the probable design of that marvellous monument.

The founder of this school was John Taylor, of London, a man of sincere piety and considerable ability, and not without some pretensions to scientific attainment; but its great apostle and prophet has been and is Prof. C. Piazzi Smyth, of Edinburgh, Astronomer Royal of Scotland. According to the teachings of this school, the object for which the pyramid, commonly known as the Pyramid of Cheops, and commonly supposed to be the tomb of that monarch, was erected, was to embody and perpetuate forever a system of metrology, — a system of divine institution, having for its unit-base the ten-millionth part of the earth's polar semi-axis, this unit being divided into twenty-five so-called pyramid inches, each greater in length than the present British inch by one one-thousandth part (a quantity to ordinary observation imperceptible). The natural inference is, that the British inch, and therefore ours also, which is identical with it, is the still surviving representative of that original and divine type, from which accordingly we have derived this interesting measure by inheritance; the slight deviation at present observable in it, from its primeval value, being a corruption which has crept in during the long ages of darkness which have intervened since the day when the builder of the Pyramid prosecuted his stupendous task under the immediate guidance of the supreme wisdom.

To those who accept this doctrine, the preservation of the British measures (corrected for the trivial error into which they are observed to have fallen) is, of course, matter of conscience; and it follows that to such, the metric system is not merely less desirable than the present, from the point of view of convenience or utility or elegance, but is a great deal worse than that — is, in fact, impious and abominable. Regarding it in this light it is easy to see how strong a temptation besets the holders of this theory to mix up, and as far as possible identify, the metric system with the horrors of the revolution of 1792. The manner in which they do

it is well illustrated in the following passage from the work of Prof. Smyth, entitled "Our inheritance in the Great Pyramid," edition of 1874, pp. 217 *et seq.*

"Before the flood, according to the Bible, there was no division of mankind into nations; *that* was a divine appointment afterwards, together with the creation of their tongues, the appointment of their bounds, and, there are good reasons for believing, the assignment of their weights and measures. And if that *was* the case, a direct and intentional effort by men to subvert them now entirely, is not likely to succeed, however many scientists put their shoulders to the wheel.

"But the French metrical system, in its acts and ambitions, is precisely such an attempt in these days to dethrone the primeval system of weights and measures amongst all nations; and make all mankind speak in future in that new and artificial metrological language, invented only eighty years ago in Paris. And if there is sound reason for believing in the divine appointment of the ancient systems, this new antagonist to them *ought* to have been ushered in under some very contrary influence.

"How, then, was it brought to the light of day?

"By the wildest, most bloodthirsty, and most atheistic revolution of a whole nation, that the world has ever seen. And, attempt to conceal it as they may, our present meek-looking but most designing promoters for introducing the French system amongst us (and I hear from Birmingham that there is a lady also among them, loudly petitioning Government for its compulsory establishment, forsooth, over our whole nation) those meek-looking geniuses, I say, cannot wipe out from the page of history, that, simultaneously with the elevation of the metrical system in Paris, the French nation (as represented there) did for themselves formally abolish Christianity, burn the Bible, declare God to be a non-existence, a mere invention of the priests, and institute a worship of humanity, or of themselves, under the title of the goddess of reason; while they also ceased to reckon time by the Christian era, trod on the Sabbath and its week of seven days, and began a new reckoning of time for human history in years of their then new French republic, and in *decades* of days so as to conform in everything to their own decimal system, rather than to revelation.

"Mere human telling was not enough to remind our British metrical agitators of those fearful things: so they have had them not sounded again only, but repeated too in fact, within the last three years, in blood and fire and blackest of smoke throughout the same city of Paris, — when the Commune, on getting for a time the upper hand, immediately reëstablished the Republican era as against the Christian, and declared war against every traditional observance and respect of man. While since then, the still more savage and merciless proceedings of the Spanish commune, wherever it has had an opportunity of rising in their cities, shows that the heart of man, unregenerated in

Christ, is no whit better in the present day than at any epoch throughout all antiquity.

"Now, perhaps — and without pursuing any further this historic part of the subject of weights and measures, which, though as old as Cain and Seth, if not Abel also, is by no means yet played out on the stage of time — it may be given to a favored, predestined few, to begin to understand, on a figure once used by Dr. Chalmers, what extensive armaments of what two dread opposing spiritual powers may be, without our knowledge, engaging in battle around our little isle, contending there — on this subject, too, as well as many others — for mighty issues through all eternity. So that, not for the force of the sparse oratory emitted in defence of British metrology before Parliament, were the bills of the pro-French metrical agitators so often overthrown, but for the sins rather of that high-vaulting system itself; and to prevent a chosen nation, a nation preserved through history thus far by much more than the wisdom of its rulers — to prevent that nation unheedingly robing itself in the accursed thing; and unknowingly throwing away an institution which it was intended to keep until the accomplishment of the mystery of God touching the human race."

The same writer, in commenting later on in his work upon a statement which he happens to have recently encountered, and which seems to have caused him much chagrin, showing with what wonderful rapidity the metric system has been gaining ground among the nations during the last thirty years, gives utterance to his discontent in the following strain: —

"This result has by no means come about altogether spontaneously, or through unseen and only natural influences; the mind of man has had much to do with it, and it has been the one polar point to which French ambition has alone been steady and true during the last eighty years; always working for it, whether sleeping or waking; whether in war or peace; always endeavoring to throw the net of her metrical system of weights and measures over other nations as well as her own people; and, though not without some imperial ambition to chain many conquered nations to the chariot wheel of France, yet with the far deeper communistic feeling of converting all the nations of the earth into one great people, speaking one language and using but one weight and one measure, and that of human, as directly opposed to divine, origination.

"France has been consistent in her own case; she had begun, at her first revolution, by slaughtering off all the accessible individuals of her reigning family; who, as such, were the very type and symbol to the French people of their being a *nation*, one amongst many nations; or of their living under that post-Babel institution. Having then, at that dreadful close of the last century, killed off, as far as she then could, all her royal family, her priests also,

and openly abrogated belief in the God of Scripture, she (France) could, at that time, of all nations consistently, and with show of demonstrable reason, become the champion of the metric, or anti-nation-existence metrological system; a system since then everywhere secretly adopted by the socialists, internationalists, communists in all countries; and, strange to say, by certain scientific men also, in some cases claiming, in others scorning to be reputed Christians.

"The task of spreading this nationally suicidal scheme over all the nations of the world might seem at first quite Quixotic; and would be, but for schemes and forces in the destiny of man, which man knows little or nothing about, until they have accomplished their ends and left him to rue their effects. So that it is owing at least as much to those unseen influences as to the direct action of any visible Frenchman, that the French metric system has been going forward during the last few years of history at a continually accelerated rate; and that one country after another has been persuaded to adopt it, until suddenly it has been found, to our exceeding astonishment and practical isolation, that almost every nation in Europe, and many peoples in Asia, Africa, and America, have already been converted."[1]

Now, it need hardly be said that no one could speak in terms of so immeasurable loathing and execration of any innocent creation of human genius, having nothing whatever in its aspect to shock or repel, but commanding on the other hand the admiring approval of some hundreds of millions of his fellow-men, unless he were so thoroughly possessed and mastered by the spirit of fanaticism as to be incapable of the exercise of judgment or of ordinary common sense, or of contemplating with patience the simple facts of his-

[1] The work from which we are quoting furnishes the most remarkable testimony we have anywhere encountered to the wonderful progress made within the last ten years, not in the world outside of England only, but in the public sentiment of England itself, by the metric system. The tone of distress, and almost of dismay, with which this testimony is given is a sufficient guaranty that the facts of the case are not exaggerated. As an example, let the following passage be taken, which is an interpolation introduced into the second edition of the work, published in 1874, the first having appeared ten years earlier.

"Thus far, nearly, was written in the first edition of this book, published in 1864; but now, in 1773–4, what is the state of matters?

"Well, their condition is surely most passing strange; for, bill after bill has been brought into Parliament, agitators have been at work throughout the land, defections from the national cause have occurred by the thousand, scientific men have turned coat, and those who a few years ago gave the most splendid testimony that to force foreign measures on the British people would aggravate them to the extent of civil war, those who in an earlier state of society would have died rather than abandon their best opinions and patriotic creeds — have now been signing propositions on the

tory which conflict with history as painted by his wild and delirious imagination. Of course it would be no better than a waste of breath to ask such a person to reëxamine the subject in the light of reason; but the mass of mankind are fortunately unblinded by prejudice, and desirous only of knowing the truth.

Now, the truth happens to be that this hated metric system, so far from having been the invention of infidels, atheists, communists, or social or political incendiaries of any sort, originated with a 'Christian bishop;[1] so far from having derived its legal existence

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other side, and even assisting in putting up at the Palace of Westminster, side by side, copies of the British and French standards of length, as though the government of France ruled already over half of the British people.

"Other renegade scientific men encouraged too by some of the chief scientific societies, have been publishing new text-books in science for, if possible, all the schools and colleges in the empire; wherein, though they still condescend to use the English language, they scorn to be loyal to the English authorized weights and measures; but speak of everything in the heavens above and the earth below in the new French metrical terms, which they seem to have sworn together they will make this country accept, whether it likes it or not.[1] While in the elementary schools which are now springing up under government headship and School-Board management all over the country, teachers are urged, induced, encouraged from some secret quarters to take time, with its expected political changes, by anticipation, and teach all the children within their reach at once the French weights and measures; or when they cannot do that, openly in defiance or prostitution of what the schools were established for, at least to have some printed representation of the French system suspended in sight, as though it were soon *going to be* the law of the land.

[1] It does not impair the argument to say that Talleyrand in his personal character or his public career did not adorn the Christian name. The charge is that the metric system was a creation of atheism. The fact is that its originator was professedly a Christian, and that he never turned against religion or identified himself with the men who trampled on the cross. It is true that, in the earlier stages of the revolution, when the king himself, willingly or unwillingly, was revolutionary, he espoused the cause of the third estate, assisted in some degree in fanning the excitements of the hour, and used or abused his sacred office to impart a show of dignity, or at least of decency, to some of the extravagances of the popular folly; it is true that like the king he later made oath to the constitution, and drew down upon himself in consequence the thunders of the Vatican; but when at length the folly passed into madness, when the monarchy was assailed and the person of the monarch himself was imperilled, his sympathy with the movement ceased, and he, too, was in danger. Becoming an object of suspicion, he sought shelter from the impending violence beneath the ægis of British hospitality, and was inscribed on the list of emigrés and enemies of the Republic.

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1 In the letters which have appeared in "Nature," from H.M.S. the *Challenger's* scientific expedition, carried on at an expense of not less than £20,000 a year to the British people, those contemned individuals have the distances steamed over by their British ship, by means of British coal, described to them in *kilometers;* and even a little piece of chalk, brought up by the dredge from the ocean-bottom is defined for size to British readers by fractional parts of a *meter*.

from the act of a king-killing or priest-murdering convention, it was decreed by the constituent assembly of France — a body which ceased to exist two years before the Reign of Terror began — and was approved by the "most Christian" king himself; instead of having been conceived with the selfish design of promoting crafty schemes of French ambition, it invited, and from the first earnestly sought to enlist in its execution, the concurrent action of all Christian nations — an endeavor which, so far as the distracted condition of European affairs at that time permitted, was entirely successful; instead of having been "brought to the light of day by the wildest, most bloodthirsty and most atheistic revolution of a whole nation that the world has ever seen," its operations were arrested by the outbreaking of that revolution; and its geodesists, already well advanced in their work, were seized and imprisoned as enemies of the republic, narrowly in fact escaping the cruel fate which actually befel their illustrious compeers, Bailly and Lavoisier;[1] finally, instead of having been at any time or anywhere a system "secretly adopted by socialists, internationalists, and communists," or a system favorite with those dangerous classes, all history may be challenged to furnish the slightest shadow of proof of this most astoundingly reckless assertion; while the attempt to confound or identify the metric system of weights and measures with the calendar of the republic, which was a later and entirely independent creation of an entirely different legislative body, argues either ignorance on the part of one who makes it, or a dis-

[1] Delambre, in charge of the northern section of the arc, after being detained and otherwise molested, was left at liberty but interdicted from further proceedings. Moreover, by a decree of Robespierre and his colleagues, he was deposed, along with his associates, Laplace, Lavoisier, Borda, and others, from the Commission of Weights and Measures, as being "deficient in Republican virtues and hatred of kings." Méchain, charged with the southern section of the survey, found his way, after his release, into Spain, where he busied himself upon the portion of the arc lying within Spanish territory, and with the latitude of its terminus at Barcelona. The work in France remained in suspension for fifteen months; and when, afterwards, the jealous oligarchy who tyrannized over the so-called republic, at length sullenly permitted its resumption, there did not follow a moment until after the final downfall of the ruling demon of the period, in which its conductors were not in imminent danger of their lives. Of Delambre, Professor Galloway remarks, that he prosecuted his task "with a resolution and courage of which the annals of science afford few examples." (*Encycl. Brit.*, Art, *Figure of the Earth*). And Principal Forbes, after speaking of the gigantic nature of the undertaking in itself considered, describes the more seri-

ingenuousness which is little in harmony with the character of a self-constituted champion of the religion of the Bible.

It is quite natural that, after the undisputed reiteration, for twelve or fifteen years, of nonsense and rhodomantade like that exemplified in the passages above quoted, it should have become habitual with the maligners of the metric system to tell us over again the old story of cutting off kings' heads, and shooting priests, and burning the Bible, and abolishing the Sabbath, and scouting the existence of God, and worshipping a courtesan under the title of the Goddess of Reason, as often as they recur to the subject. And hence it occasions us no surprise to find in the report of the majority of the committee of the Franklin Institute, the customary indictment in the formidable words following: —

"The new system was struck out during the red heat of the revolution, during which the king was dethroned and beheaded, the nobles were killed wherever found, and their property, when they fled for their lives, was plundered and confiscated. The priests were driven from their cures, and religion was abolished. The Christian era disappeared, and the world began again at the year *one* of the French Republic, upon the 22d of September, 'the day of the autumnal equinox, when the sun entered the sign of the *Balance*, the symbol of equality.' However favorable to the introduction of a perfect system of weights and measures, your committee hope that no such opportunity may be presented in this country."

The minority report of Mr. Briggs is sensible and brief, and is

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ous impediments to its progress and the personal dangers to its conductors arising from political causes, as follows: — "But difficulties greater than physical obstacles presented themselves to the completion of this vast work. The excited state of the public mind during the most frenzied period of the French revolution rendered the simplest operations matters of suspicion. The nearer to Paris the survey was carried on, the greater were the precautions necessary. Instruments were seized, assistants arrested, and night signals had to be totally dispensed with. The coolness and intrepidity of Delambre, added to unexampled patience, were the principal means of extricating him from his difficulties; but his danger was often imminent, and he appears to have sometimes heard the dreadful words, which, as an eloquent author has expressed it, 'were the last sounds that vibrated in the ear of many an unhappy victim.'" (*Sixth Preliminary Treatise, Encycl. Brit.*)

These facts may throw some little light upon the relation between the blood and blasphemy of the French revolution and the metric system.

confined principally to a protest against the representations and conclusions of the majority; as to its perversion of history, as to its statements in regard to the convenience, suitability, or permanency of our present complicated and diverse measures and weights, "and especially as to the averment that the 'common mind' can estimate these irrational and disconnected magnitudes more perfectly than those which have simple and definite multiples and relations." The author further protests against the assumption of the majority that it is only the scholar or the scientific or professional man who desires the introduction of the metric system, while the practical man does not need it and does not want it; affirming that the truth is directly the reverse. And he concludes by remarking that "the universal introduction of the metric system is only a question of time," — a remark the correctness of which must be obvious to the slightest consideration of the progress of the past.

The Institute, nevertheless, adopted the report of the majority, and in doing so placed itself on record as the only organized body, having any generally recognized claim to scientific character, which has distinctly declared itself opposed to the further progress of the metric reform.

Passing to the list of Associations whose responses to the Boston society were unequivocally favorable, it is interesting to observe how large a number of these belong to the medical profession, — the profession in which precision in weight is of the highest importance, and whose appreciation of the merits and defects of systems is likely to be most intelligent. Among these may be mentioned the Boston Society of Medical Sciences; the Boston Society for Medical Observation; the Boston Homœopathic Medical Society; the Maine Medical Association; the New Haven Medical Association; the St. Louis Medical Society; the St. Louis Medico-Chirurgical Society; the St. Joseph's Medical Association, Missouri; the Alameda County Medical Association, California.

In addition to these, from which communications were directly received, the committee record the action of others as reported through the public journals. Among the notices of this kind the following is particularly interesting: —

"The American Pharmaceutical Association, at its last annual meeting, appointed a permanent committee of three to favor 'an early and concerted action for the compulsory introduction of the metric standards;' to coöperate with other Associations and the government; to recommend that a knowledge of the metric system be required for admission to schools of pharmacy; to request writers for the Association to put metric values into their papers and reports; and to solicit chemical and pharmaceutical manufacturers 'to add metric equivalents to the present amount of weights on the labels of their original packages and vials; and to adopt, at their earliest convenience, a change in the amount of their products put up and sold in small original packages or vials, using metric instead of avoirdupois weights. This change would not require an alteration in the size of vials now in common use.'"

The other societies which returned favorable responses were the New England Association of Gas Engineers, the Engineers Club of St. Louis, the Microscopical Society of San Francisco, the Middlesex Mechanics Association at Lowell, Mass., the Belles Lettres Society of the Illinois Wesleyan University, and the Mt. St. Mary's Seminary of the West at Cincinnati. The report also states that the Society of Arts of the Massachusetts Institute of Technology had petitioned Congress to appoint a commission on the subject and that the Massachusetts Association of Classical and High School Teachers had adopted a memorial identical with that of the Boston Society itself. The committee conclude their report with the very judicious observation that, "after advising so many other people to use the metric weights and measures, we think it would be a graceful thing for the members of the Society" to use the same themselves; and they accordingly recommend that, upon all plans prepared by the members, there should be given a scale of meters as well as a scale of feet. This recommendation could be only improved by suggesting that the scale of feet be omitted.

The interest felt and the progress made among the members of the various scientific professions in the country, is not, however, to be measured by reckoning up the number of organizations of this character which have, down to this time, declared themselves upon the subject by formal resolution. Many have had it from time to time under discussion informally, some have devoted entire sessions to its more elaborate treatment, during which carefully prepared written papers have been presented, and the arguments on both sides have been set forth with much ability; some have appointed

committees to consider the subject exhaustively, and to report on the advantages and disadvantages of the proposed change; with instructions, in occasional instances, to correspond with other organizations at home and abroad, and to collect facts for the information of their own members.

Thus a committee was appointed as long ago as 1876 by the American Institute of Mining Engineers, to inquire and report upon a standard gauge, — an inquiry which at once brought up the question as to the unit of reference to which the dimensions of gauges should be made to conform. The members of the committee — Prof. Thos. Egleston of the Columbia College School of Mines, Chairman, and Messrs. Wm. Metcalf, and J. D. Weeks — entered into a very extensive correspondence, not only with persons interested in the manufacture and use of gauges in this country, but also with the governments of England, France, Germany, Russia, and Austria. Their report, presented to the Institute in October, 1878, demonstrates very clearly the absence of uniformity in the gauges in use and the great necessity of reform; but when we look for the conclusions of the committee as to what the nature of the reform should be, we find that, like Rasselas after an inquiry equally protracted, the committee unfortunately arrive at length only at "a conclusion in which nothing is concluded;" which they gravely formulate by recommending "the adoption of the system of expressing sizes in thousandths of an inch, or fractions of a millimeter." The American Institute of Mining Engineers seems therefore, up to the present time, to be on both sides of this interesting practical question.

For the last three or four years the Civil Engineers Club of the North-west, having its head-quarters at Chicago, has had the question of the adoption of the metric system under consideration without having as yet come to any direct vote by which the general sense of the club could be tested. It has devoted several entire sessions to the discussion, and the published reports give evidence that the debates have been both able and animated. At the November meeting of 1878 there was presented by a member, Mr. Soulerin, one of the most sensible and admirably reasoned papers in favor of the system that has yet appeared in any quarter. On the other hand, Mr. Charles Latimer, another member,

deprecated the adoption of the system, complimenting the intelligence of its advocates by remarking that he "verily believes them to be men who are *entirely unaware of the inextricable confusion into which we would be plunged by such an act;*" not forgetting to add, moreover, the usual damnatory observation, that "the French system is the fruit, and I may say, the untimely fruit, of a revolution," which, of course, leaves nothing further to be said. Mr. Latimer, however, seems disposed to say something further, and accordingly he proceeds to kick the system after it is down, by submitting to the meeting the well-known letter of Sir John Herschel to the London *Times*, discussing "the comparative *de facto* claims of our British unit and of the French, on abstract scientific grounds," and concluding in favor of the British.

It seems a little strange that the irrelevancy of arguments like these to the real, practical, pressing question actually before the world, never seems to occur to the men who use them. Nobody is making any war on the British units "on abstract scientific grounds." Nobody disputes, for example, that a very good international and universal system of practical metrology might have been constructed upon the British foot, provided the nations had seen fit to adopt it. No one doubts that a system which would have answered the purposes of the world might have been constructed on the Egyptian cubit, or the Russian archine, or the Flemish ell, with the same proviso. The question before us is, not what might have been, but what may possibly be. Now, to urge the adoption of the British units as the basis of universal metrology, is the idlest waste of breath that can possibly be conceived. It may, therefore, be well inquired what practical good these people propose to themselves to accomplish, by bewildering men with laborious calculations to prove that the British foot and the British pint and the British pound are in approximate relations, more or less simple, with the earth's polar axis; and that if all mankind would only adopt these units, we should get along very well.

The Club, though coming to no vote upon the main question, adopted before adjourning the encouraging resolution to instruct their secretary to provide printed stationery bearing metric devices, for the use of the members.

The Troy Scientific Association (Troy, N.Y.,) has recently undertaken to organize a national committee to consider and report on the question of a standard for micrometry. In announcing this purpose, through the chairman of their Microscopical Section, Dr. R. H. Ward, the Association remark, that "naturally the most important, if not the only difficult, question will be to decide whether the time has come when the country is ready, or can be made ready, to adopt the metric system in this work." There can be very little doubt as to the conclusion at which this committee will arrive.

The Kansas State Teachers' Association, resolved, in 1877, that this Association recommend and strongly urge the teachers of Kansas to study and teach the decimal or metric system of weights and measures, with a view to its early adoption throughout the State.

The Ohio State Teachers' Association, in 1877, resolved as follows: — *Whereas*, The progress of commerce and the general diffusion of knowledge demand common terms for the expression of quantity, and

Whereas, In the opinion of the Ohio Teachers' Association the introduction of this system into general use will be of incalculable benefit to the interests of society; therefore be it

Resolved, That in order to prepare the way for the general adoption of this system of weights and measures throughout our State, we earnestly recommend that instruction in it be given a place, early in our courses of study, and that all of our pupils be made practically familiar, not only with the terms used, but also with the weights and measures themselves.

Resolved, That inasmuch as the chief interest in the metric system arises from its practical value in actual use in commerce and trade, as well as in the arts and sciences, we recommend all actually to use these weights and measures in their own affairs, so far as convenient, and also to urge upon and encourage others to do the same, as in this way only can the system become generally diffused among the people.

Resolved, That we make thankful acknowledgment to the Press of this State for the aid given in familiarizing the people with the principles and advantages of this system, and that we seek the same powerful ally in the future. To the end that the greatest

good may be done in the least time, we hereby request each managing editor in the State to place himself in communication with the American Metric Bureau of Boston.

Resolved, That we respectfully petition the General Assembly of the State of Ohio so to amend the school law that all teachers shall be required to pass an examination in the metric system of weights and measures before obtaining a certificate.

The Franklin County (Ohio) Teachers' Association indorsed the foregoing resolutions of the State Teachers' Association, and petitioned the General Assembly to so amend the school law that all teachers shall be required to pass an examination in the metric system of weights and measures.

The Preble County (Ohio) Teachers' Association adopted the following: — *Whereas*, "Divers weights, and divers measures, both of them are alike abomination to the Lord." — Prov. xx: 10.

Resolved, 1. That true economy demands an easy method of computation in business transactions.

2. That the metric system of weights and measures is such a method that its use would save time in every department of industry, in which arithmetical computations are made.

3. That its introduction into business affairs would take from our arithmetics the long and useless tables of our present system of compound numbers, thereby saving valuable time to the child.

4. That the legislature should render instruction in the system obligatory, in the public schools.

5. That without waiting for such legislation, all school authorities should provide for instruction in the system in the schools under their charge by furnishing the necessary apparatus.

6. That all teachers should agitate the subject of its universal introduction, and to this end should become thoroughly acquainted with the system, so that they may talk intelligently about it and instruct, correctly, their pupils or any person desiring to study the system.

7. That the subject should be taught at all teachers' institutes, and taught and talked about at all teachers' associations.

8. That the county board of school examiners should now require a knowledge of the system as a condition of receiving a first or second-class certificate.

THE CINCINNATI SOCIETY OF NATURAL HISTORY resolves, that a standing committee on the international system of measures and weights be appointed at the May meeting of each year; and that in all communications presented to this Society, it is recommended that, as far as possible, dimensions should be expressed in units of the international or metric system.

Also, that whereas, the Board of Education of Cincinnati has taken active measures to secure thorough instruction in the international system of measures and weights; therefore, that this Society express its cordial approbation, with the sincere hope that the course thus inaugurated may be developed (as experience may dictate), so as to become a permanent part of the curriculum; that the grateful acknowledgments of this Society are hereby extended to the Board of Education, the Superintendent of Schools, and to the teachers who have thus undertaken an additional burden; and that the following memorial be signed by the officers and transmitted to our Representatives, on behalf of our Society: —

To the honorable Senate and House of Representatives of the United States in Congress assembled: —

Whereas, The international or metric system of weights and measures is the best that can be adopted for convenience, simplicity, permanence, and uniformity with other nations;

Whereas, Bills have recently been introduced to secure the use of the system in several of the executive departments of the United States Government, and

Whereas, Such action would not only be expedient in itself, but would also have an important influence by bringing this subject to the notice of a large number of citizens, thus enabling them to realize the advantages of the system, and encouraging its adoption for general use;

Therefore, Your memorialists most respectfully beg that your honorable body may speedily take such action in the premises as may seem most expedient to secure the general adoption of the metric system by the citizens of this country; and particularly that steps be taken for the introduction of this system into the various

departments of the public service, such as the Post Office, Custom House, War Department, and Coast Survey.

The medical profession of the county and state of New York have for many years past been growing more and more favorable to the substitution of metric weights and measures, for the in many ways inconvenient system heretofore in use. In 1876 Dr. Henry G. Piffard, an accomplished young physician of the city, published in the *Medical Record* a series of communications, in which he not only pointed out the imperfections of the so-called apothecaries' weight, but further showed, from the results of extensive personal examination, that the weights themselves in actual use, in many, if not in most of the drug stores of the city and country, are inaccurate to a degree which is absolutely scandalous. He concludes, therefore, that there is crying necessity for a reform of some kind; and that since we have not really the benefit of the bad system we are supposed to have, no state of things could be more propitious to the introduction of a new and a good one.

But among the able and enlightened members of the profession in New York, who have labored longest and most efficiently in the cause of this reform, no one deserves a higher place than Dr. Edward Seguin, a physician and philanthropist of world-wide reputation, well known for his devoted labors and signal successes in the education of the imbecile and idiotic, a department of philanthropic effort in which he was the pioneer. Dr. Seguin, in a report on education as illustrated in the Vienna Exposition of 1873, published among the official reports of the United States Commissioners, insisted on making the instruction of children in measures of quantity a practical and effectual thing, by placing in the hands of the learners, or directly under their eyes, the instruments of measurement themselves — the meter to be taken as the unit-base.

More recently he has been urging upon the members of his own profession, through their periodical international congresses, the adoption of a system of universal uniformity in medical observation, nomenclature, formularies, pharmacopœia, posology, clinical notes, weights, measures, and all else that concerns either the theory or the practice of medicine. To facilitate individual conformity to such a system, he has prepared and published note and prescription books for the pocket, in which to record observations

under all the various heads of temperature, pulse, respiration, sleep, condition of the skin, tongue, etc., with observations as to food, drink, and medication, at each successive visit to the patient; thus preserving a continuous written history of the case, with duplicate forms also for prescriptions, one of which is a removable coupon, the other being retained in the book. The basis of all measures of quantity in this system is, of course, the metric.

At a meeting of the Medical Society of the County of New York, held in December, 1878, Dr. Seguin was appointed chairman of a committee on the metric system, "to report as soon as possible on the feasibility of the application of the metric system to medicine, and of bringing American physicians to a practical uniformity with those of other countries." The committee immediately issued a circular, which was addressed extensively to members of the profession, expressing a desire "to collect information and to gain the cöoperation of other pharmaceutical or medical organizations," and also "to be brought into direct communication with the committees of those societies which have (or will have) the same object in view;" and, in conclusion, setting forth the form of a resolution for the adoption of the metric system, which they design to propose to the Medical Society of the County of New York.

This movement has not, at the moment at which these pages go to press, reached its culmination. The following particulars in regard to its progress have been obligingly furnished by Dr. Seguin.

On the 6th of February, 1879, the New York State Medical Society at Albany responded to the communication of the county society by the adoption of the following resolution: —

"The New York State Medical Society requests of those who present papers at its future meetings that the metric system be employed in their communications, and that this system be *exclusively* used in the published proceedings of this Society.

"'By this first official act,' say the committee in their report, 'your Metric Committee has gained for its object (the exclusive use of the metric system in medicine) the sanction of the highest medical authority of this state.'

"Already in 1876 the Medical Society of the State of Massachusetts had adopted the metric system; and since, the Rhode Island State Medical Society has voted the obligatory use of the metric system within the limits of its jurisdiction, and other state medical societies are preparing similar resolutions.

"This advance is not purely local, but English as well. In a leading article the London *Lancet* of November 23, 1878, gives a formal adhesion to the use of the metric system in medicine; and in its issue of February 1, 1879, expatiates on 'the very great boon which would accrue to the medical profession by the introduction of metric weights and measures, and by the abandonment of the *grotesque* and *obsolete* system which is now in vogue.'

"The editor of the *British Medical Journal* writes to us (February 4, London): ' . . . . . I hope that I may be able to excite sufficient interest on the subject here to bring about practical measures. I shall be aided by your progress, and I should be glad to hear details."

The following extracts from an earlier report of the committee are interesting, not only for the general considerations which they embrace, but for the particular facts which they detail, most of which are additional to those we have ourselves gathered and presented above. Speaking of the metric system, the committee say: —

"Its adoption is unavoidable but its postponement would bear on the intellectual position of thousands of American and country practitioners, who without this common standard measure are cut short of what is truly new and mind-stirring in modern medicine, — its mathematism. This self-excommunication works in two ways: by the hardship of translating one system of measurement into another in the course of reading; and by the medical papers omitting to reproduce the best European observations, because it would cost too much care and money to translate their figures from the metric to the English.

"On another hand, this barrier of heterogeneous figures deprives the labors of our country from their deserved publicity and timely recognition — as it did those of the first American ovariotomists, and of the first ingenious village dispensators of 'our' remedies — by deterring the European press from publishing results long ago obtained here. This could not have happened had we in time — that is, long ago — accepted the metric system, which is exclusive French no more, but international forever — as far as the word can go in futurity. This said for personal interest, let us consider the interest of our profession.

"The Metric System is *the part* of medical uniformity which must be first adopted if we want to be actively participant in the great events just preparing in the medical world. New theories, discoveries, and inventions; new instruments of observation, of operation, of analysis, and of registration; new remedies and old ones made new by modern modes of preparation and for recent applications, equally require that we make use of a uniform and fixed quantitative and volumetric standard.

"This standard cannot be the English, which is discredited even in England.

"It can be but the metric system and language — not only on account of the

invariableness of its unit, the meter, but because of its systemic homogeneity, which permits to operate at once 'on the decimal basis' upon any of its quantitives or volumetric symbols or figures without precalculations, and with unerring accuracy. These *qualities* of the metric system are so commanding that they have secured for it the patronage of twenty nations, and of all the men of science (physicians excepted) in England and America.

"As for England, now but too late conscious of the damage caused to the fame of her great surgeons and excellent physicians, by her clinging to obsolete weights and measures, she is ready, says the London *Lancet*, to adopt the metric system in medicine and pharmacy.

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"The Treasury Department United States Marine Hospital Service, represented by its Surgeon-General, Woodworth, and by Assistant Surgeon Francis H. Brown, has tendered a cordial assistance, and sent us (that is, for you) several hundred 'metric slips,' which are here at your disposal. The U.S. Metric Bureau of Boston, and its branch in New York, have helped us too.

"The American Ophthalmologic Society has adopted the metric system in its convention of 1876.

"Several professors of medicine use the metric system in their courses: John C. Dalton, Chandler, Otis, E. C. Seguin, of the College of Physicians and Surgeons of New York, and many others who have not given us an opportunity of naming them; others promise to use the metric system, as Dr. Mary P. Jacobi, of the New York College and Hospital for Women.

"The professors of pharmacy and chemistry — Drs. Squibb and Maisch, of Philadelphia, and Rice, of Bellevue Hospital, teach the metric system.

"The New York County Medical Society, upon the initiative of Dr. Piffard, resolved, December, 1876, that its members be instructed to use the metric system. . . . .

"The Syracuse (N.Y.) Medical Association resolved (April, 1877) that the metric system be used in prescribing, and in all communications to the Society. Then, quietly, the medical college of the same city began to teach the metric system, and by the metric system.

"The Rhode Island State Medical Society has just resolved, that on and after the 1st of January, 1880, its members will adopt the metric system. In Massachusetts all the profession seem ready to apply this system, and it is but the 30th of January last that the Boston City Hospital Society had a meeting to sanction its introduction in the hospitals.

"Not less remarkable, though a little behind, comes the intention expressed by the secretaries of state and county medical societies to have the question of the adoption of the metric system discussed at their next meeting.

"And more to be pondered over is the *proviso* contained in several letters, and tersely expressed in Dr. F. Morse's, Secretary of the Kansas Medical Society: 'We approve of the metric system; some of our presidents have warmly urged its use, but we wait for the example of older states.'

"From so grouping these documents according to their meanings, one can follow the current of the medical mind. Earnest commencement of teaching and prescribing in the metric language; eminent professors of medicine, pharmacy, and chemistry using it in the chair; state and county medical societies expressing their readiness to adopt the metric system, only waiting for the great old states to assume the initiative. Is not our New York state great, old, and learned enough to be one of the leaders in this revolution?

"If one argues against the metric system that it has not been taught in our medical colleges, that does not speak ill of the system, but of the colleges. The application of the metric system to medicine can be comprehended in half an hour, and become familiar in a week; and, as Professor John C. Dalton expresses it, 'No one who had once employed it practically could ever use any other.'"

The following resolutions, recommended by the committee, are still pending before the County Society, with no doubt of their speedy adoption: —

Resolved, That the metric system shall henceforth be used in the minutes of this Society, and in all the papers published under its authority.

Resolved, That the Medical Society of the County of New York request the medical boards of the hospitals and dispensaries to adopt the metric system in prescribing, and that the Faculties of the medical colleges in this city be also requested to order its adoption in their didactic and clinical departments.

Resolved, That the Medical Society of Kings County be invited to cooperate with this Society in the means of insuring safe and rapid transition from the old to the new system of weights and measures in medicine and accessory sciences.

The American Medical Association, at a meeting held in Buffalo, June 5, 1878, unanimously resolved that this section, recognizing the value of the metric system for its uniform, international, indestructible, generally applicable, convenient, simple, safe, and scientific character, hereby recommends to all physicians the use of the same in their practice, and in their writings and teachings.

The National College of Pharmacy, at their annual meeting held in Washington in April, 1878, on motion of Dr. Oscar Oldberg, whose able report on the subject to Surgeon-General Woodworth has been mentioned on page 231 of this volume, resolved that in the future revision of the United States Pharmacopœia, the metric system of weights and measures ought to be exclusively employed in the determination of quantities, and that the term

"gram" and "centigram" only should be used for weights, and the term "cubic centimeter" for measures.

This section cannot more fitly terminate than by presenting the following resolution, adopted by the United States Board of Trade, at a meeting held in New York City on the twelfth day of February, 1879, on motion of Mr. Nathan Appleton, of Boston: —

Whereas, The general adoption of the metric system of weights, measures, and coins by all nations is a mere matter of time, it having been computed and stated by competent authorities that the system is now used by more than half the inhabitants of the globe; and

Whereas, Any nation that does not introduce this system in place of any other, is keeping itself behind the age, and suffering the logical consequences. It is, therefore,

Resolved, That the United States Board of Trade recommends the study and use of the metric system to the citizens of the land. It urges the importance of having this system taught in all schools, colleges, and institutions of learning. It recommends that the government of the country should put it into practice in all business connected with the custom-houses. It further recommends that the system should be universally adopted in the Post Office Department for domestic postage, as is already the case with foreign postage. This can be done by having fifteen grams substituted for half an ounce, and so on in progression for all mail matter. It is further of the opinion that the coinage of the country should be made metric. A change of three-tenths of one per cent. will make the present gold coins metric in accordance with a bill now before Congress. The silver coins (except the dollar) are metric already, and copper coins can also be easily and advantageously altered to become a part of the metric system.

Section 5.—THE METROLOGY OF THE PAST.

Nothing is more characteristic of the general progress of civilization throughout the world, than the gradual disappearance of those numerous differences between different peoples which relate to matters purely conventional. There are differing peculiarities of race, which being dependent on physiological or climatic causes, will probably never be obliterated. Differences of complexion, of stature, of mental and moral temperament, will probably always continue to exist. But the manners and customs, the social usages, the instrumentalities of commercial interchange, the laws, the governments, all things in short, which are subject to human control, tend steadily to assimilate themselves to each other, and give constantly increasing ground for the belief, that in most respects the world is yet to become entirely uniform as to its social organization, as to its political institutions, and possibly even as to its language.

The history of the past has shown us a progress in this direction of which we are scarcely conscious, until we begin to enumerate to ourselves the very many particulars in regard to which all civilized nations are already agreed. The late eminent publicist, Dr. Francis Lieber, has called attention to this tendency in a communication addressed, in Aug. 1871, to the editor of the *Revue de Droit International*, in which he quotes from his previously published works in English, the following passage, which (not having been able to find it in its place) we here re-translate. He says, "The modern nations of our group" (meaning the Caucasian) "have arrived at concordance in very many things, and this concordance goes on constantly augmenting. We have the same alphabet, the same numerals, the same system of notation both arithmetical and musical, the same division of the circle and of time, the same maritime league, the same barometer, the same mathematical language, an identical science of music and of the fine arts, a common system of education as well superior as primary, the same abstract science, the same division of governmental powers, the same principles of domestic economy, the same descriptions and fashions of garments, the same manners, the same toys for children (Asia and Africa have no toys, or at least none for children only); we are

connected by a common postal and telegraphic service; we are tending more and more to uniformity of weights and measures, moneys and maritime signals; we have the same ideas in financial matters to such a degree that all the grand *bourses* of commerce have acquired the character of international reunions wielding an influence at least equal to the diplomatic; we have an international law of literary property which is rapidly extending; a law of private property perfectly recognized abroad; in fine, we have a common international law, binding even during war. Add to this that we possess really one literature, which may be justly called international, and in which a Shakspeare, a Kepler, a Franklin, a Humboldt, a Grotius, and a Voltaire appertain equally to the entire cis-Caucasian race. We have a common history of civilization; and Columbus as well as Frederic, Napoleon as well as Washington, appertain to us all for our benefit or our misfortune."

There is thus existing and has for some centuries existed a steady tendency towards uniformity of usages, uniformity of laws, and uniformity of modes of thought, among the entire group of cis-Caucasian or mainly Christian nations, which the progress of enlightenment in our own time has stimulated to a very high degree. Hitherto its operations have been difficult and tardy. "The history of simplification and of unification," says Dr. Lieber, "is an uninterrupted history of difficulties slowly and progressively vanquished, in the laws of succession, in general laws, in customs, in measures, in moneys — in short in everything. In the middle ages the law of succession varied, not only from one town to another, but even from one side to the other of the streets, as the different populations had thus originally established themselves. Rostock was an example of this. Each place had its different measures and its different methods of calculation, and frequently the same place had different descriptions of weights for different descriptions of merchandise." [This state of things, as appears from debates in the British Parliament, still prevails to a large extent in many rural districts of Great Britain, notwithstanding the efforts which have been made by parliamentary enactments since this century began, to enforce uniformity.] "The books of arithmetic in use in the English schools give to this day an appalling number of measures for different objects; but in the meantime

uniformity, gradually gaining ground, has pervaded towns and provinces and larger areas, until finally whole countries have made it their rule, in their laws, in their measures, and in their moneys. This is the point at which we stand at present."

What remains is to make this same uniformity the rule of the whole world. In respect to systems of weight and measure, the progress toward international uniformity is already very signal. On the continent of Europe, from the Atlantic coast to the Russian boundary, if we except the little peninsula of Denmark, but a single system prevails; yet within the area here embraced, there existed, three quarters of a century ago, a state of confusion in this matter little less than chaotic. The character of this chaos can in no way be better illustrated than by presenting, as is done below in tabular form, the immensely numerous varieties of value which have heretofore been attributed to certain particular units of measure everywhere called by the same name.

The first of these tables is devoted to the *foot*. The measure called by this name was first introduced in pre-historic times in ancient Greece. A unit similarly denominated has been practically the basis of every European system of linear measurement since the period of the Roman conquests in Germany, Gaul, and Britain. Even in the country of its origin, however, the length of the foot measure was by no means everywhere the same; and in later times, the different values assigned to it have been almost as numerous as the towns or districts in which it has been employed. The values given in the table below have been gathered from numerous authorities, including Kelly, Tate, Nelkenbrecher, Paucton, Altés, Tarbé, Doursther, and others. The table includes all the foot measures which have been at any time in use, so far as known. By far the greater number belong to Europe; but a few are derived from the East, from South America, and from the southern hemisphere. Two or three in the list are of comparatively recent origin, having been derived from the metric system within the present century. These were adopted in Switzerland and in some of the minor states of Germany, with a view to render the local systems commensurable with the metric. The total number of values embraced in the table amounts to two hundred and eighty-two, of which there were actually in use a century ago no fewer than two

hundred and seventy-six, and of these two hundred and sixty-six belonged to countries which have since adopted the metric system. All this great number must be counted as having become obsolete since the century began, most of them within the past twenty or thirty years. Those which still survive belong to the United States, Great Britain and her dependencies, and to the Russian Empire. Nothing could more strikingly illustrate the power of that tendency towards uniformity among civilized nations of which we have spoken above, than an examination of this list and a consideration of the contrast it presents between the actual state of things in Europe, at this time, and that which existed on that continent previously to the foundation of the first French Empire. It is not pretended that this enumeration is entirely exhaustive; but it embraces all the different values for which authorities have been found. In some instances, in which the same measure is given by different authorities for the same place, there occur slight discrepancies between them. In these cases, both values are entered in the table, because both have been derived from standards actually in use, and it would be impossible to discover which, if either, has the higher claim to authenticity. This is only to say that the differences are real, and therefore that, in a complete exhibit, both values ought to be retained.

We have, however, in the consideration of this fact, a suggestion of one of the causes which have probably been instrumental in producing this enormous diversity. It has been due, doubtless, in great measure to so imperfect a system of governmental control, and such a neglect of the necessary inspection and verification, at frequent intervals, of the public standards, as has naturally left the door open to the introduction of actual differences between measures intended to be, and supposed to be, of the same dimensions. We have an example of this kind in the case of the *Feldmassfuss* of Aix-la-Chapelle, which Doursther gives as 282.0 mm.; and Gattey as 282.1 mm.; also in the ordinary foot of Nivelles, which Kelly gives as 277.0 mm., while Renard and the official tables of the department of Jemappes give it as 277.09 mm. Other similar examples will be detected by glancing along the columns of the table. But such cannot have been the origin of the differences generally observed, although these differences throughout are so

slight as to give to the table the appearance of a scale of prismatic wave-lengths.

The explanation above suggested could only apply to measures slightly differing, in the cases in which they are found in the same place, or at least in the same neighborhood. When, on the other hand, slight differences are observed to occur in towns geographically separated so far from each other as Carrara, in Italy, where the foot is 293.3 mm., and Hainaut, in Belgium, where it is 293.4 mm., we must presume that these measures, and consequently their differences, originated independently of one another. A similar example of this character is found in comparing the foot of Valentia, Spain, which is 302.33 mm., with that of Linz, in Austria, where it is 302.9 mm. Again, the foot of Pernau, Russia, is 274.3 mm., and that of Bruges, Belgium, 274.4 mm.; the foot of Amsterdam, Holland, is 283.1 mm., and that of Dresden, Saxony, 283.26 mm.; the foot of Bar-le-Duc, France, is 294.4 mm., and that of Ancient Rome, 294.3 mm.; the foot of Cracow, Poland, is 356.4 mm., and that of Bordeaux, France, 356.74 mm., etc. In cases like these it is impossible to suppose the measures cited, trivial as the differences are, to have had a common origin.

In contrast with this we often find, in the very same place, two or more foot-measures so largely different that there can be no doubt of their entirely independent origin. These, which are usually, and almost invariably, incommensurable with each other, were severally employed for different purposes. Thus, at Lucerne, besides the foot for ordinary uses of 313.85 mm. (the extensively used *pied du Rhin*), there was a carpenters' foot of 303.86 mm., and a builders' and surveyors' foot of 284.23 mm. At Berne, the foot for ordinary purposes was equal to 293.26 mm., and the *steinbrecherfuss*, or quarry foot, to 317.7 mm. At Audenarde, Belgium, there was the carpenters' foot 292.00 mm., the masons' foot 297.7 mm., and the surveyors' or agrarian foot 285.1 mm. Cassel had *two* agrarian foot-measures, one of 284.9 mm., and another of 398.9 mm., while the foot for ordinary use was 287.7 mm. These varieties added greatly to the confusion of ideas, when dimensions were stated in feet. But this confusion was still further increased by the fact that the necessities of business

required the people of each locality to employ, more or less, the measures of other localities. Thus, the foot-measures of capital cities and the greater marts of trade, as of Paris, Brussels, Vienna, Hamburg, Frankfort-on-the-Main, Antwerp, Cologne, and others, were very generally known and used throughout Central Europe. The latter, commonly called *the foot of the Rhine*, appears to have been more extensively employed than any other. It was made the legal foot for the Kingdom of Prussia, and prevailed over nearly all the states of Germany and large portions of Switzerland, as well as in Copenhagen (Denmark), Christiania (Norway), and St. Petersburg, Moscow, and Nijni-Novgorod, in Russia.

It will be observed that the larger foot measures are found chiefly in Italy. Beyond the limits of that kingdom no such measures employed for ordinary mechanical purposes exceed fourteen inches, with the exception of those of Cracow, Bordeaux, Franche Comte, Dordrecht, Trent, Tessin, and Geneva; of which the first four are slightly in excess of fourteen, and the last three belong to towns in close connection with Italy. Those which exceed this limit in the more northern countries, as for instance the large foot of Berlin, 14.828 in.=376.62 mm., and that of Halle 17.046 in. =432.95 mm., are agrarian measures. The large foot measures of Italy may perhaps be explained by considering the intimate relations which existed during the early centuries between that peninsula and Northern Africa, Egypt, and the Levant, where the unit of length has always been the cubit. The Romans appear to have borrowed the measures of the East, but to have applied to them names with which they were already familiar; so that the cubit became the foot. Still, the city of Rome has retained down to the present century the foot of the Empire very slightly changed; the modern Roman foot being 11.729 in. =297.9 mm. and the ancient 11.595 in. = 294.5 mm. The foot of Carrara is only 11.548 in. =293.3 mm.; and in many other Italian towns, especially in the states of the Church, the foot is below fourteen inches, and in some below thirteen.

It need hardly be said that the diversity of measures of surface, of capacity, and of weight, in use in past centuries in the different countries of Europe, and since discarded for the metric measures,

has been no less remarkable than the table below shows it to have been for those of length. Superficial measures in fact, being usually the squares formed upon the length-measures, had of course the same variety as these last. Weight measures and capacity measures, however, being in all the old systems of metrology entirely independent, had of course, their own systems of diversity. In the case of weight, as in the case of length, a common name, the *pound*, was employed to denote the ordinary unit throughout the continent. The name of the ordinary capacity unit, however, varied from country to country; so that, although the same degree of discord existed among capacity measures as among the others, there did not co-exist with it the anomaly of an endless diversity where the nomenclature seemed to furnish a guarantee of identity.

Table II. gives a view of the varieties of pound weight once, or still in use, very many of them long since superseded by the kilogram, but of which some, though a much smaller number, still survive. In this list we see even more strikingly than in the case of length measure, the needless multiplication of differing measures of the same name in the same place. In every place there were at least two different pound weights; in many places there were three, and in some as many as four, five, six, or even seven. Stockholm, in Sweden, for example, had this number, viz.: a pound weight for provisions (*wiktualjewigt*) of 423.54 grams; a customs-pound (*stapelstadswigt*) of 338.8 grams; a mining pound (*bergwerkwigt*) of 374.4 grams; a city pound (*landstadswigt*) of 356.6 grams; a pig-iron pound (*råjernwigt*) of 486.7 grams; a raw copper pound (*råkopparwigt*) of 375.9 grams; and finally a pound for drugs and medicines of 355.0 grams. Frankfort-on-the-Main had six, viz.: a wholesale pound of 505.3 grams; a retail pound of 467.9 grams; a fish-market pound of 511.7 grams; a meat and butter pound of 482.5 grams; a flour and malt pound 481.0 grams, and a medicinal pound of 357.5 grams; this last having been originally the pharmaceutical pound of Nuremberg, adopted later by common consent for all Germany.

Among localities having five different pounds, may be named Alicante and Valentia, in Spain; Dresden and Leipzig, in Saxony; and Hof in Bavaria. Among those having four, Nuremberg in

Bavaria; Basle in Switzerland; and Grenoble in France. Among those having three, Augsburg in Bavaria; Amsterdam in Holland; Schaffhausen in Switzerland; Mannheim in Baden; the Ionian Islands, and many others.

The table also furnishes us abundant examples of the growth of diversities from the carelessness or unskilfulness with which standards have been constructed, or from want of exactness in their verification by the proper authorities. Thus there can be no doubt that the pound of Madrid, the pound of the Asturias, the pound of Carthagena, the pound of Teneriffe (a Spanish Island), and the pound of Cadiz, are all of them varieties of the old legal pound of the Kingdom of Castile. It is impossible nevertheless to ascertain which of these values corresponds to the original value of that old pound; or whether this is true of any one of them. The pound given as that of Madrid, viz., 7100 grains = 460.07 grams, was determined by a standard *marc* (half pound) of Madrid, sent to London in 1818 by the British Consul General at that capital, and verified at the mint. The Carthagena pound is given in accordance with a determination made by Kelly from a comparison of many standards of which he took the mean. The Cadiz pound is from a value given by Altés as having been verified in 1830 at the prefecture of Marseilles. Finally, the Teneriffe pound, for which the authority is Kelly, was determined from a standard of ten pounds in weight sent to London and verified there. The year of this last determination is omitted. The pound of Corunna, 460.9 grams, came without doubt, from the same source, and possibly that of Gibraltar, 461.5 grams; but that of Constance, Switzerland, 460.56; that of Amiens, France, 461.4 grams; and that of Lindau, Bavaria, 461.8, were all probably of independent origin.

The total number of differing values for the pound weight contained in this table is three hundred and ninety-one. The total number which have been superseded by the kilogram is three hundred and seventy.

It will, of course, be understood that the several foot-measures and pound-weights given in these tables were used more or less extensively in the villages and towns adjacent to those named in the list. It is not always easy, therefore, to determine to which locality each most distinctively belongs. Thus the pound of Aurich, Han-

over, 496.8 grams, which is in the list, is equally the pound of Leer, seventeen miles distant from it. Also the commercial pound of Liège, Belgium, 467.1 grams, is also the pound of Charleroi in the same kingdom, and of the adjacent town of Maubeuge, in France. Such examples are numerous.

It is further to be noted that in these tables it has been impracticable to notice the special objects for which the several foot-measures or pound-weights were employed; or, in other words, to distinguish them as surveyors' measures, builders' measures, etc., or as commercial weights, jewellers' weights, druggists' weights, market weights, etc. All these are arranged indiscriminately in the order of their values.

TABLE I. — *The* FOOT MEASURE *at different periods and in different localities.*

Where used.	British Inches.	Millimeters.	Where used.	British Inches.	Millimeters.
Delphos, Greece (anc.)	7.276	184.8	Nivelles, Belg.	10.909	277.09
Wesel, Prussia	9.254	235.06	Neustadt, Bav.	10.910	277.1
Altorf, Switz.	9.299	236.2	Alost, Belg.	10.914	277.2
Avignon	9.759	247.87	Teralphene, Belg.	10.931	277.65
Aix en Provence	9.786	248.57	Duffel, Belg.	10.945	278.0
Hesse Darmstadt	9.843	250.0	Worms, Darmst.	10.949	278.1
Saragossa, Spain	10.118	257.0	Mannheim, Baden	10.957	278.3
Duren, Prussia	10.358	263.1	Castile	10.958	278.33
Jaghire, India	10.460	265.68	Heilbronn, Wurt.	10.964	278.5
Reval, Russia	10.471	265.96	Burgos, Spain	10.970	278.64
Utrecht, Neth.	10.563	268.3	Osnabruck, Han.	10.995	279.27
Zug, Switz.	10.580	268.7	Heidelberg, Baden	11.003	279.35
Chalons, sur Marne	10.658	270.7	Mechlin, Belg.	11.004	279.5
Dunkirk, Belg.	10.757	273.22	Bruchsal, Baden	11.010	279.65
Bergues, Fr.	10.774	273.65	Maestrecht	11.020	279.9
Ypres, Belg	10.784	273.9	Hildesheim, Han.	11.031	280.2
Riga, Russia	10.791	274.08	Bamberg, Bav.	11.041	280.45
Pernau, Russia	10.800	274.3	Madrid, Spain	11.047	280.6
Bruges, Belg.	10.803	274.4	Muhlhausen, Prussia	11.057	280.85
Wetzlar, Prussia	10.815	274.7	Rheims, Fr.	11.084	281.53
Ghent, Belg.	10.839	275.3	Aix-la-Chapelle (2)	11.102	282.0
Gozée, Belg.	10.853	275.65	Aix-la-Chapelle	11.107	282.1
Brussels, Belg.	10.856	275.75	Metz, Germany	11.114	282.3
Termonde, Belg. (1)	10.866	276.0	Lima, Peru	11.122	282.5
Ostend, Belg.	10.870	276.09	Curaçao	11.125	282.57
Nivelles, Belg. (2)	10.906	277.0	Leipzig	11.128	282.66

[1] The foot of Termonde, East Flanders, 276.0 mm, and that of Ostend, West Flanders, 276.09 mm, differ so slightly that they may very probably have had a common origin.

[2] The authorities generally give the foot of Nivelles as 277.0 mm; Renard, and the official tables of the Department of Jemappes, (now called Department of Hainaut) give it as 277.09 mm.

[3] Doursther and the authorities generally give the agrarian foot of Aix-la-Chapelle = 282.0 mm; Gattey makes it = 282.1 mm.

Where used.	British Inches.	Millimeters.	Where used.	British Inches.	Millimeters.
Buenos Ayres	11.129	282.67	Bienne, Switz.	11.508	292.3
Fulda, Hesse	11.137	282.88	Calenburg, Hanover	11.510	292.35
Ruremonde, Belg.	11.142	283.0	Nordhausen, Prussia	11.524	292.7
Amsterdam	11.146	283.1	Bingen, Hesse	11.504	293.1
Dresden, Saxony	11.150	283.26	Nuremberg, Bav.	11.541	292.15
Magdeburg, Prussia	11.164	283.56	Berne, Switz.	11.546	293.26
Malta	11.167	283.63	Carrara, Italy	11.548	293.3
Breda, Neth.	11.186	284.13	Hainaut, Belgium (4)	11.551	293.4
Lucerne, Switz.	11.191	284.23	Mons, Belgium	11.553	293.43
Frankfort-on-Main	11.205	284.61	Wurtzburg, Bav.	11.564	293.7
Hesse Cassel	11.217	284.9	Treves, Prussia	11.565	293.75
Stettin, Prussia	11.223	285.09	Bar-le-duc, France	11.580	294.4
Audenarde, Belg.	11.225	285.1	Rome (anc.)	11.595	294.5
Brunswick	11.235	285.36	Liège, Belgium	11.603	294.7
Diest, Belg.	11.240	285.5	Namur, Belgium	11.605	294.76
Louvain	112.41	282.51	Alsace	11.614	295.0
Haarlem, Neth.	11.253	285.8	Luxemburg	11.622	295.2
Lorraine, Germany	11.259	285.93	Clèves, Prussia	11.635	295.5
Oppenheim, Darmst.	11.264	286.1	Oldenberg	11.645	295.88
Gera, Reuss.	11.268	286.2	Moravia	11.652	295.96
Hamburg	11.279	286.5	Augsburgh, Bav.	11.661	296.2
Antwerp,	11.293	286.8	Prague	11.670	296.4
Dantzic, Prussia	11.295	286.9	Stockholm	11.688	296.87
Aix-la-Chapelle	11.303	287.1	Galicia, Austria	11.691	296.96
Neufchatel, Switz.	11.305	287.15	Thorn, Prussia	11.706	297.3
Wiesbaden	11.311	287.3	Audenarde, Belg.	11.721	297.7
Greel, Belg	11.315	287.4	Calais *(pied de Comte)*	11.723	297.77
Aschaffenburg, Bav.	11.319	287.5	Douay, France	11.725	297.8
Dusseldorf, Prussia	11.323	287.6	Schaffhausen, Switz.	11.728	297.88
Gotha	11.324	287.62	Rome, Italy	11.729	297.9
Bois-le-duc, Neth.	11.326	287.67	Holstein, Germany	11.750	298.45
Cassel	11.327	287.7	Anspach, Bav.	11.803	299.8
Glatz, Prussia	11.333	287.84	Zurich, Switz. (5)	11.812	300.0
Lubeck	11.335	287.9	Zurich, Switz.	11.8656	301.38
Prussian Silesia	11.337	287.96	Flessingen, Baden	11.8666	301.4
Poland	11.339	288.0	Valentia, Spain	11.903	302.33
Culm, Prussia	11.343	288.1	Linz, Austria	11.9.6	302.9
Aix-la-Chapelle	11.350	288.5	Nuremburg	11.963	303.86
Halle, Prussia	11.364	288.63	Rio de Janeiro	11.966	303.94
Landau, Bav.	11 368	288.75	Eichstadt. Bav.	11.970	304.04
Mannheim, Baden	11.370	288.8	Nuremberg, Bav.	11.973	304.1
Spires, Bav.	11.374	288.9	Basle	11.990	304.54
Ulm, Wurtemburg	11.377	288.97	England and U. S.	12.000	304.79
Bremen	11.386	289.2	Durchheim, Bav.	12.012	305.1
Montbelliard, France	11.390	289.3	Larr, Baden	12.025	305.4
Austrian Silesia	11.395	289.42	Oppenheim, Darmst.	11.032	305.6
Lippe Detmold	11.398	289.5	Benfelden, France	12.034	305.67
Duderstadt, Hanover	11.413	289.9	Scotland (ancient)	12.065	306.44
Zenlenrode, Reuss	11.417	290.0	Montebello, Italy	12.094	307.2
Mannheim, Baden	11.426	290.2	St. Gall, Switz.	12.108	307.54
Coblentz	11.442	290.6	Königsburg, Prussia	12.114	307.7
Munster, Prussia	11.448	290.8	Athens (anc.)	12.126	308.0
Carlsruhe, Baden	11.457	291.0	Trèves, Prussia	12.203	309.95
Friedburg, Darmst.	11.477	291.5	Zierickzee, Neth.	12.221	310.4
Liège, Belgium	11.488	291.8	Rotterdam	12.301	312.43
Munich, Bavaria	11.491	291.86	Ratisbon, Bav.	12.345	313.56
Celle, Hanover	11.496	292.0	Cologne *(pied du Rhin)*	12.357	313.85
Alzey, Darmstadt	11.500	292.1	Besancon, France	12.391	314.74
Groningen, Neth.	11.504	292.2	Austria	12.445	316.1

[4] The foot of the province of Hainaut is given by Dourstber as 293.4 mm; the foot of Mons, capital of Hainaut, is given by the *Regulateur du Hainaut*, (Mons, 1831) as 293.43 mm.

[5] In 1820 the builders' foot of Zurich was made = 301.38 mm; the ordinary foot was equal to 133 Paris lines = 11.812 Br. in. = 300.0258 mm. The law of 1851, which adopted the value of 300 mm as the foot of the Republic, produced therefore no sensible change in this unit for Zurich.

Where used.	British Inches.	Millimeters.	Where used.	British Inches.	Millimeters.
Urbania, Italy	12.460	316.5	Rovigo, Italy	15.127	382.23
Freiburg, Baden	12.469	316.7	Cento, Italy	15.609	396.45
Innspruck, Tyrol	12.505	317.6	Tessin, Switzerland	15.631	397.0
Berne, Switz.	12.508	317.7	Hesse Cassel	15.704	398.9
Trieste, Austria	12.523	318.07	Jesi, Italy	15.759	400.26
Arabia (anc.)	12.599	320.0	Ferrara, Italy	15.900	403.85
Vienne, France	12.700	322.58	Treviso, Italy	16.067	408.1
Paris *(pied de Roi)*	12.789	324.84	Ancona, Italy	16.125	409.57
Hautes Alpes	12.799	325.1	Fermo, Italy	16.711	424.46
Fossombrone, Italy	12.827	325.8	Bagna-Cavallo, Italy	16.957	430.7
Lisbon, Portugal	12.944	328.77	Halle, Prussia	17.046	432.95
Oporto, Portugal	12.992	330.0	Milan, Italy	17.134	435.2
Burgundy	13.040	331.2	Bergamo, Italy	17.235	437.77
Aveyron, France	13.071	332.0	Imola, Italy	17.310	439.66
France *(pied usuel)*	13.124	333.33	Morbegno, Italy	17.567	446.2
Hautes Alpes	13.128	333.45	Pergola, Italy	17.591	446.8
Botzen, Tyrol (6)	13.154	334.1	Como, Italy	17.765	451.2
Botzen, Tyrol	13.162	334.3	Lodi, Italy	17.927	455.33
Moscow, Russia	13.171	334.54	Vigevano, Italy	18.204	462.38
Cagli, Italy	13.193	335.1	Lippe-Detmold	18.237	463.2
Briel, France	13.198	335.2	Mantua, Italy	18.381	466.86
Chambery, Savoy	13.362	339.4	Crema, Italy	18.496	469.8
Porto Gruaro, Italy	13.405+	340.49	Piacenza, Italy	18.500	469.9
Cividale, Italy	13.405—	340.5	Novara, Italy	18.542	470.95
Dauphiny	13.426	341.0	Brescia, Italy	18.544	471.0
Bonneville, Savoy	13.469	342.1	Mortara, Italy	18.581	471.95
Agen, France	13.477	342.3	Cotignola, Italy	18.706	475.1
Lyons, France	13.484	342.5	Camonica, Italy	18.720	475.47
Genoa, Italy	13.485	342.51	Alexandria, Piedmont	18.771	476.78
Verona, Italy	13.501	342.9	Faenza, Italy	18.889	479.77
Aquila, Italy	13.535	343.8	Fano, Italy	18.910	480.3
Polcenigo, Italy	13.541	343.95	Cremona, Italy	19.036	483.5
Samos, Archipelago	13.624	346.04	Casal, Piedmont	19 056	484.0
Guienne, France	13.640	346.45	Offida, Italy	19.057	484.04
Aviano, Italy	13.677	347.4	Bormio, Italy	19.095	485.0
Venice	13.691	347.74	Geneva, Switzerland	19.210	487.94
Pesaro, Italy	13.706	348.13	Forli, Italy	19.221	488.2
Russia (7)	13.748	349.2	Massa-Carrara, Italy	19.519	495.78
Babylon (anc.)	13.780	350.0	Nassau (duchy of)	19.685	500.0
Le Perche, France	13.855	351.9	Morro di Valle, Italy	19.790	502.65
Latisana, Italy	13.928	353.76	Genoa, Italy	20.227	513 77
Frankfort-on-Main	14.007	355.76	Recanati, Italy	20.523	521 27
Cracow, Poland	14.033	356.4	Loretto, Italy	20.533	521.3
Bordeaux	14.045	356.74	Modena, Italy	20.593	523.05
Hanau, Cassel	14.053	356.95	Chiavenna, Italy	20.756	527.2
Bassano, Italy	14.071	357.4	Reggio, Italy	20.902	530.9
Franche Comte	14.075	357.5	Mirandola, Italy	20.942	531.9
Russia (8)	14.135	359.0	Cesena, Italy	21.200	538.47
Dordrecht, Neth.	14.173	360.0	Guastalla, Italy	21.363	542.6
Fort Marlborough	14.400	365.75	Rimini, Italy	21.376	542.95
Trent, Austria	14.406	365.9	Parma, Italy	21.444	544.67
Feltre, Italy	14.451	367.05	Gualtieri, Italy	21.525	546.74
Canton, China	14.625	371.47	San Leo, Italy	21.989	558.5
Berlin, Prussia	14.828	376.62	Ravenna, Italy	23.016	584.6
Osimo, Italy	14.952	379.78	Lucca, Italy	23.225	589.9
Bologna, Italy	14.965	380.1	Cervia, Italy	25.565	649.33

[6] Dourther gives the foot of Botzen = 334.1 mm, and Nelkenbrecher gives it = 334.3 mm.

[7 8] These were foot measures of the Russian empire before the metrological reform introduced by Peter the Great, who adopted the English foot.

TABLE II. — *The* POUND WEIGHT *at different periods and in different localities.*

Where used.	Grains.	Grams.	Where used.	Grains.	Grams.
China (anc.)	2963.0	192.0	Recanati, Italy	5086.5	329.6
Crema, Italy	4126.6	267.4	Locarno, Switzerland	5098.1	330.35
Mechlin	4208 4	272.7	Botzen, Tyrol	5102.7	330.65
Brussels	4271.6	276.8	Ancona, Italy	5105.0	330.8
Mons	4310.3	279.3	Monaco, Italy	5113.5	331.35
Antwerp	4353.5	282.1	Fano, Italy	5142.1	333.2
Capua, Italy	4376.6	286.3	Lucca, Italy	5169.8	335.0
Gaeta, Italy	4552.5	295.0	Trent, Tyrol	5185.3	336.0
Ravenna, Italy	4623.5	299.6	Sinigaglia, Italy	5200.7	337.0
Belluno, Italy	4648.72	301.2	Stockholm, Sweden	5228.5	338.8
Venice, Italy	4649.8	301.3	Padua	5230.0	338.9
Rovigo, Italy	4651.3	301.4	Rome, Italy	5233.1	339.1
Tortosa, Spain	4701.5	304.65	Bologna, Italy	5237.7	339.4
Turin	4743.9	307.4	Florence, Italy	5240.1	339.55
Cremona, Italy	4768.6	309.0	Modena, Italy	5250.1	340.2
Como, Italy	4787.1	310.2	Roveredo, Tyrol	5257.8	340.7
Nice, Piedmont	4808.7	311.6	Lucca, Italy	5262.4	341.0
Mantua, Italy	4870.4	315.6	Civita Vecchia	5265.5	341.2
Malta	4885.9	316.6	Bassano, Italy	5269.4	341.45
Genoa	4892.0	317.0	Pontremoli, Tuscany	5299.5	343.4
Sicily	4900.5	317.55	Lisbon	5312.6	344.25
Piacenza, Italy	4907.5	318.0	Alicante, Spain	5324.2	345.0
Ionian Islands	4908.3	318.05	Madrid	5330.3	345.4
Bucharest	4949.2	320.7	Ferrara, Italy	5337.3	345.85
Naples	4949.9	320.75	Genoa	5380.5	348.65
Palermo, Sicily	4950.08	320.76	Perugia, Italy	5382.8	348.8
Brescia, Italy	4953.8	321.0	Massa-Carrara, Italy	5383.6	348 85
Sienna, Tuscany	4961.5	321.5	Aragon	5398.2	349.8
Raconigi, Piedmont	4986.2	323.1	Eng. (Tower Pound) [1]	5400.0	349.91
Rome (anc.)	5000.1	324.0	Aragon	5401.3	350.0
Reggio, Modena	5015.5	325.0	Berlin	5412.9	350.75
Pisa, Italy	5027.9	325.8	Stockholm	5478.5	355.0
Bergamo, Italy	5032.5	326.1	Valentia, Spain [2]	5484.0	355.36
Parma	5037.1	326.4	Alicante, Spain	5493.9	356.0
Milan	5043.3	326.8	Stockholm, Sweden	5503.2	356.6
Parma	5061.8	328.0	Berne	5505.5	356.75
Forli, Italy	5083.4	329.4	Soleure	5518.6	357.6

[1] The Tower-pound, so called, was the pound of the mints in England previously to 1526. In this year, under Henry VIII., it was replaced by the Troy pound. This tower pound was of eastern origin — hence called Easterling or Sterling — and was introduced into England in the time of Richard Cœur de Lion. Camden in his Britannia says, "In the time of Richard the First, monie coined in the east parts of Germanie began to be of especiall request in England for the puritie thereof, and was called Easterling monie, as all the inhabitants of those parts were called Easterlings; and shortly after, some of that countrie, skillfull in mint matters and allaies, were sent for into this realme to bring the coine to perfection; which since that time was called of them sterling for Easterling."

[2] The value here given for the Valentia pound of twelve ounces, viz., 355.36 grams = 5484.0 grains, was determined at the London Mint, from an authentic standard, in 1818. Altés, from a standard said to be authentic, verified in 1829 at the prefecture of Marseilles, makes it exactly 356.0 grams = 5493.9 grains Troy, which is also the pound-weight of Alicante. Valentia had, in fact, four different pound-weights employed for different purposes, all of them multiples of the ounce; being equal, severally, to twelve, sixteen, eighteen, and thirty-six ounces. The ounce appearing to have been equal in 1818 to 29.613 grams = 257 grains, and in 1829 to 29¾ grams = 457.827 grains, all the four derivative pounds differed correspondingly. The large pounds of 1066 grams and 1068 grams were used for bread and provisions.

Where used.	Grains.	Grams.	Where used.	Grains.	Grams.
Nuremburg, Bavaria .	5522.5	357.85	Memel, Prussia	6374.3	413.05
Coblentz	5523.2	357.9	Drôme, France	6389.0	414.0
Warsaw	5532.5	358.5	La Lozère, France . .	6392.1	414.2
Munich	5555.6	360.0	Nismes, France	6393.6	414.3
Bologna, Italy	5586.5	362.0	L'Herault, France . . .	6399.0	414.65
Arabia	5659.0	366.7	Haute Loire, France .	6412.1	415.5
Esterling of Charlemagne (3)	5665.2	367.1	Pernau, Russia	6429.1	416.6
Hanover	5666.8	367.2	Grenoble, France . . .	6440.7	417.35
Alexandria, Piedmont .	5692.2	368.85	Posen, Prussia	6447.6	417.8
Amsterdam	5696.1	369.1	Courland, Russia . . .	6448.4	417.85
England & United States	5760.0	373.24	Riga, Russia	6451.5	418.05
Stockholm, Sweden . .	5777.9	374.4	Lauban, Prussia . . .	6466.2	419.0
Lithuania	5782.5	374.7	Vienna, Austria	6481.6	420.0
Brussels	5787.1	375.0	Galicia, Austria	6483.1	420.1
Stockholm, Sweden . .	5801.0	375.9	Calais, France	6500.0	421.19
Salon, France	5811.8	376.6	Thorn, Prussia	6501.6	421.3
Warsaw, Poland . . .	5846.5	378.85	Abbeville, France . . .	6512.4	422.0
Aix-en-Provence . . .	5851.2	379.15	Gothenburg	6535.6	423.5
Jever, Oldenburg . . .	5860.7	379.7	Stockholm, Sweden . .	6536.2	423.54
Var, France	5864.3	380.0	Douay, France	6558.7	425.0
Königsburg, Prussia .	5882.8	381.2	Montauban, France . .	6568.8	425.65
Ragusa, Dalmatia . . .	5906.0	382.7	Thielt, Flanders	6595.8	427.4
Tarascon, France . . .	5989.3	388.1	Clermont, France . . .	6609.7	428.3
Arles, France	6037.9	391.25	Chambery, Savoy . . .	6620.5	429.0
Orange, France	6043.3	391.6	Moissac, France	6622.8	429.15
Gap, France	6049.5	392.0	Dixmude, Belgium . .	6635.9	430.0
Apt, France	6134.4	397.5	Tournay, Belgium . .	6645.2	430.6
Lublin, Poland	6147.5	398.35	Courtray, France . . .	6652.6	431.0
Pillau, Prussia	6164.5	399.45	Lille, France	6656.0	431.2
Patras, Greece	6166.8	399.6	Görlitz, Prussia	6668.4	433.4
Catalonia, Spain	6174.0	400.07	Bautzen, Saxony . . .	6689.9	433.5
Barcelona, Spain (4) . .	6188.4	401.0	Ghent	6695.3	433.85
Jaroslaw, Austria . . .	6230.0	403.7	Murcia	6710.0	434.8
Vienne, France	6236.2	404.1	Embrun, France . . .	6713.1	435.0
Lenczicz, Poland . . .	6252.4	405.15	Dantzig, Prussia . . .	6720.8	435.5
Breslau	6256.3	405.5	Dresden, Saxony . . .	6725.4	435.8
Cracow, Poland	6264.0	405.9	Zierickzee, Netherlands	6734.7	436.4
Wiburg, Russia	6270.8	406.1	Villefranche, France .	6740.85	436.8
Cagliari, Italy	6273.2	406.5	Audenarde, Belgium .	6819.55	441.9
Toulon, France	6274.0	406.55	Renaix, Belgium . . .	6821.1	442.0
Haute Garonne, France	6294.9	407.9	Grenoble	6832.7	442.75
Aveyron, France . . .	6296.4	408.0	Grenada, Spain	6835.0	444.2
Avignon, France . . .	6307.2	408.7	Dinant, Belgium . . .	6946.1	450.1
Teralphene, Belgium .	6314.9	409.2	Dover	6955.0	450.68
St. Petersburgh	6318.0	409.4	Dresden	6961.5	451.1
Castres, France	6358.1	412.0	Travancore, India (5) .	6972.0	451.78
Uzès, France	6359.7	412.1	England and U. S. . . .	7000.0	453.59
Beaucaire, France . . .	6372.0	412.9	Travancore, India (6) .	7007.5	454.08
			Nancy, France	7032.5	455.7

[3] The name of this pound indicates also an eastern origin, but there is no eastern pound with which it can be at present identified. It continued to be used as the pound of pharmacy in France till superseded by the kilogram.

[4] Altés, whom Dourstber follows, states that an authentic pound-weight of Barcelona, carefully verified at the prefecture of Marseilles in 1829, gave 401.0 grams as the exact value. He says, however, that a steel-yard and weight sent to London by a commercial house expressly for the trial, gave as a result, 6174.0 grains = 400.07 grams, which is the pound of Catalonia, as determined from an authentic standard in the London Mint. Both weights were doubtless in use.

[5 6] The first of these pound-weights, 6972.0 gr. = 451.78 grams, according to Dourstber, is that by which the *circar* (government) receives pepper from the natives; the second, 7007.5 gr. = 454.0 grams, is that used by the same authorities in selling their pepper. It strikes us as a little remarkable that the selling unit should be greater than the buying unit; and one might be tempted to suspect that the terms had been inverted.

Where used.	Grains.	Grams.	Where used.	Grains.	Grams.
Poperingen, Belgium .	7040.2	456.2	Flessingen, Baden . . .	7245.9	469.4
Vienne, France	7049.5	456.8	Durbuy, Belgium . . .	7246.3	469.55
Madeira	7075.7	458.55	Glaris, Switzerland . .	7250.1	469.8
Lyons, France	7081.9	458.9	Cambrai, France . . .	7253.2	470.0
Lisbon, Portugal . . .	7083.45	459.0	Bois-le-duc	7254.7	470.1
The Asturias (7)	7098.88	460.0	Antwerp, Belgium . .	7256.3	470.2
Madrid (8)	7100.0	460.07	San Lucar, Spain . . .	7259.4	470.4
Carthagena, Spain . . .	7101.0	460.14	Mentz	7263.2	470.65
Teneriffe	7103.5	460.3	Wiesbaden	7264.0	470.7
Cadiz	7106.6	460.5	Copenhagen	7266.0	470.83
Constance, Baden . . .	7107.5	460.56	Bienne, Switzerland . .	7271.7	471.2
Corunna, Spain	7112.8	460.9	Biel, Alsace	7274.8	471.4
Amiens, France	7120.5	461.4	Strasburg	7276.4	471.5
Gibraltar	7122.0	461.5	Erfurt, Prussia	7284.0	472.0
Lindau, Bavaria	7126.7	461.8	Meissen, Saxony . . .	7285.6	472.1
Grisons, Switzerland .	7137.5	462.5	Augsberg, Bavaria . .	7294.9	472.7
Ivica (Mediter.)	7145.2	463.0	Bourg-en-Bresse . . .	7296.4	472.8
Leuze, Belgium	7158.3	463.85	Lauffenburg	7298.0	472.9
Bruges, Belgium . . .	7159.1	463.9	Valencia, Spain	7312.0	473 81
Diest, Belgium	7160.6	464.0	Alicante, Spain	7325.7	474.7
Appenzell	7176.0	465.0	Stade, Hanover	7331.9	475.1
Ostend	7177.6	465.1	Tours, France	7341.2	475.7
Gueldres, Prussia . . .	7179.1	465.2	Berg-op-zoom, Neth. .	7342.7	475.8
Camenz, Saxony . . .	7183.8	465.5	Kiel, Denmark	7355.0	476.6
Mons	7184.5	465.55	Udine, Italy	7361.2	477.0
Bruchsal, Baden . . .	7189.2	465.85	Venice	7362.0	477.05
Valenciennes	7194.6	466.2	Nuremburg, Bavaria .	7362.8	477.1
Cleves, Prussia	7196.1	466.3	Rovigo, Italy	7365.9	477.3
Altenburg	7200.7	466.6	The Morea	7379.7	478.2
Cincy, Belgium	7201.5	466.65	Hull, England	7387.0	478.67
Dresden, Saxony . . .	7205.4	466.9	Buda-Pesth, Hungary .	7402.9	479.7
Nordhausen, Prussia .	7206.1	466.95	Basle, Switzerland . .	7410.6	480.2
Aix-la-Chapelle	7206.9	467.0	Frankfort-on-Main . .	7423.0	481.0
Liège, Belgium	7208.5	467.1	Passau, Bavaria	7426.0	481.2
Lessines, Belgium . . .	7209.2	467.15	Limoges, France . . .	7436.8	481.9
Leipzig	7209.5	467.17	Zwolle, Netherlands . .	7438.4	482.0
Brunswick	7211.5	467.3	Frankfort-on-Main . .	7446.1	482.5
Carlsruhe, Baden . . .	7213.0	467.4	Bayonne, France . . .	7453.8	483.0
Cologne, Prussia . . .	7214.6	467.5	Boitzenburg, Germany	7458.5	483.3
Berlin, Prussia	7217.7	467.7	Flensburg, Denmark .	7460.0	483.4
Stettin, Prussia	7219.0	467.78	Cassel	7473.0	484.24
Stuttgardt, Wurt. . . .	7219.3	467.8	Hamburg	7475.4	484.4
Frankfort-on-Main . .	7220.8	467.9	Lubeck (9)	7479.5	484.66
Mannheim, Baden . . .	7221.6	467.95	Lubeck	7480.06	484.7
Middelburg, Neth. . .	7222.3	468.0	Bamberg, Bavaria . . .	7492.4	485.5
Bourges, France	7227.0	468.3	Valais, Switzerland . .	7493.9	485.6
Berlin, Prussia	7230.0	468.5	Basle, Switzerland . .	7502.4	486.15
Ulm, Wurtemburg . .	7234.7	468.8	Padua	7507.8	486.5
Ath, Belgium	7237.8	469.0	Stockholm, Sweden . .	7510.9	486.7
Mechlin, Belgium . . .	7241.6	469.25	St. Sebastian, Spain . .	7531.0	488.0

[7] There are two Asturian pounds, both presumably derived from the old pound of Castile, the *libra menor* of sixteen Castilian ounces, and the *libra mayor* of twenty-four Castilian ounces. Doursther gives the *libra menor* at 460.0 grams and it is so given in the table above. Altés makes it 460.5 grams, which is the pound of Cadiz in the table. Of the two values of the *libra mayor* contained in the table, the first, 690.0 grams, is that of Doursther, and the second, 690.75 grams, is that of Altés.

[8] The pound of Madrid, 7100.0 grains = 460.07 grams, is mentioned in the text as having been derived from the ancient pound of the kingdom of Castile; and the same seems to have been true of the pound of Carthagena, of Cadiz, of the Asturias, of the Canary Islands, and others. In the uncertainty of the true value of the Castile pound, it is not included in the list, but is presumably represented by that of Madrid. Kelly, from a mean of several weights, puts it at 7101.0 grains = 460.137, which is the pound of Carthagena, as verified from a standard *marc* (half pound) in 1818 at London.

Where used.	Grains.	Grams.	Where used.	Grains.	Grams.
Orchimont, Belgium . .	7538.7	488.5	Grisons, Switzerland .	8029.5	520.3
Luneburg, Hanover . .	7546.4	489.0	Lenzburg, Switzerland	8089.6	524.2
Bilbao, Spain	7551.0	489.3	Cleves, Prussia	8108.2	525.4
Paris (*poids-de-marc*) .	7554.1	489.5	Aurich, Hanover . . .	8117.4	526.0
Calenburg, Hanover . .	7555.7	489.6	Schwartz, Switzerland	8148.3	528.0
Bastia, Corsica	7564.9	490.2	Freiburg, Switzerland .	8157.5	528.6
Augsburg, Bavaria . .	7580.4	491.2	Havre de Grace	8159.1	528.7
Morlaix, France	7581.9	491.3	Bremgarten, Switz. . .	8159.9	528.75
Ofen, Hungary	7586.5	491.6	Austrian Silesia	8173.0	529.6
Mons, Belgium	7588.9	491.75	Curaçao, W. I.	8199.2	531.3
Liège, Belgium	7593.5	492.05	Allevard, France . . .	8218.5	532.55
Amsterdam, Neth. . .	7595.2	492.16	Valencia, Spain	8226.0	533.04
Sourabaya, Java . . .	7595.8	492.2	Murten, Switzerland . .	8239.3	533.9
Scotland (anc.)	7600.0	492.47	Alicante, Spain	8240.9	534.0
Cochin, Malabar	7607.5	492.96	Iverdun, Switzerland .	8287.2	537.0
Basle, Switzerland . .	7611.2	493.2	Thun, Switzerland . .	8299.5	537.8
Wismar, Mecklenburg	7623.6	494.0	Mogadore	8305.7	538.2
Amsterdam, Neth. . .	7625.1	494.1	St. Omer	8460.8	548.25
Bordeaux	7629.8	494.4	Gessenay, Switzerland	8489.3	550.1
Nimeguen	7639.0	495.0	Geneva, Switzerland .	8498.6	550.7
Travancore, India . . .	7659.1	496.3	Grenoble, France . . .	8516.3	551.85
Aurich, Hanover . . .	7666.8	496.8	Allevard, France . . .	8527.9	552.6
Zofflingen, Switz. . . .	7686.1	498.05	Presburg, Hungary . .	8615.1	558.25
Bremen [10]	7690.0	498.3	Fiume, Austria	8622.1	558.7
Bremen	7694.4	498.59	Munich, Bavaria . . .	8642.1	560.0
Christiania, Norway .	7706.9	499.4	Vienna, Austria	8643.7	560.1
Patras, Greece	7709.2	499.55	Tyrol	8682.2	562.6
Grenada, Spain	7712.3	499.75	Linz, Austria	8742.4	566.5
Verona, Italy	7713.1	499.8	Ratisbon	8748.6	566.9
Zoll-verein	7716.17	500.0	Nyon, Switzerland . .	8827.3	572.0
Botzen, Tyrol	7731.6	501.0	Hof, Bavaria	8850.5	573.5
Tunis, Africa	7773.5	503.71	Schaffhausen, Switz. .	8873.6	575.0
Dresden, Saxony . . .	7781.0	504.2	Galicia, Spain	8882.9	575.6
Heidelburg, Baden . .	7782.5	504.3	Constance, Baden . . .	8884.4	575.7
Rheinfelden	7785.6	504.5	Corunna, Spain	8892.1	576.2
Frankfort-on-Main . .	7798.0	505.3	Lindau, Bavaria	8907.6	577.2
Mannheim, Baden . . .	7799.5	505.4	St. Gall, Switzerland .	8913.0	577.55
Petershausen, Baden .	7804.1	505.7	Appenzell	9021.8	584.6
Lausanne, Switzerland	7805.7	505.8	Amberg, Bavaria . . .	9524.8	599.7
Mechlenburg, Schwerin	7848.9	508.6	Eger, Bohemia	9251.8	617.0
Rouen, France	7856.6	509.1	Crema, Italy	9629.8	624.0
Anspach, Bavaria . . .	7861.2	509.4	Hof, Bavaria	9833.5	637.2
Rothenburg, Bavaria .	7865.9	509.7	Lahr, Baden	10348.9	670.6
Calais, France	7867.4	509.8	The Asturias [9] . . .	10648.3	690.0
Nuremburg, Bavaria .	7869.0	509.9	The Asturias	10659.9	690.75
Hassfurt, Bavaria . . .	7870.5	510.0	Grisons, Switzerland .	10707.0	693.8
Eichstadt, Bavaria . .	7872.0	510.1	Wunsiedel, Bavaria . .	10946.9	709.35
Frankfort-on-Main . .	7896.7	511.7	Milan	11767.9	762.55
Memmingen, Bavaria .	7902.1	512.05	Bellinzona, Italy . . .	12021.8	779.0
Salzburg, Austria . . .	7910.6	512.6	Malta	12216.0	791.58
Cochin, Malabar	7930.0	513.85	Mogadore	12458.5	807.3
Prague, Bohemia . . .	7939.2	514.45	Bergamo, Italy	12581.2	815.25
Belluno, Italy	7973.9	516.7	Mendrisio, Italy	12574.3	814.8
Alicante, Spain	7986.2	517.5	Lugano, Switzerland .	12668.4	820.9
Culmbach, Bavaria . .	7987.0	517.55	Barletta, Italy	13055.8	846.0
Munchberg, Bavaria . .	7987.8	517.6	Locarno, Switzerland .	13594.4	880.9
Soleure, Switzerland .	7998.6	518.3	International	15432.35	1000.0
Cronach, Bavaria . . .	8007.8	518.9	Valencia, Spain [2] . .	16450.88	1066.0
Troyes, France	8024.8	520.0	Valencia, Spain	16481.75	1068.0
Berne, Switzerland . .	8026.4	520.1	Port Mahon	18520.4	1200.1

[9] The pound of Lubeck was determined at the London Mint, from standards sent for the purpose by the British consul, to be 7479.5 grains = 484.66 grams. Another determination made by Schumacher on the spot, gives 7480.06 grains = 484.7 grams.

[10] By the verification at the London Mint (date not given) of an authentic standard pound-weight of Bremen, the weight was found to be 7690 grains = 498.3 grams. Nelkenbecher states that an ordinance of the senate, of the year 1818, fixed the pound-weight at 498.59 grams = 7694.4 grains Troy.

Weight of a Bushel in the United States.

As a supplement to the foregoing, and as an evidence of the metrological confusion from which we suffer in this country in regard to matters of interest to every farmer, the following table, prepared by J. K. Upton, Esq., Chief Clerk of the Treasury Department at Washington, to accompany the reply of the Department to the Committee on Weights, Measures and Coinage of the House of Representatives of the Forty-fifth Congress, under the resolution of the House of the 6th Nov., 1877, and showing the legal weight of a bushel of grain and other commodities in different states and territories of the United States, is here reproduced.

WEIGHT OF A BUSHEL.

REVISED TABLE SHOWING THE STATES AND TERRITORIES OF THE UNITED STATES WHICH HAVE ESTABLISHED BY LAW THE WEIGHT IN POUNDS AVOIRDUPOIS OF A BUSHEL OF DIFFERENT GRAINS AND OTHER COMMODITIES.

STATES AND TERRITORIES.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Indian-corn.	Corn on cob.	Corn-meal and rye-meal.	Bran.	Malt.	Potatoes, Irish.	Potatoes, sweet.	Carrots.	Onions.	Turnips, English.	Beets.	Beans.	Peas.	Apples, peaches, pears, and quinces.	Dried apples.	Dried peaches.	Castor-beans.	Flax-seed.	Hemp-seed.	Millet-seed.	Timothy-seed.	Blue-grass seed.	Hungarian-grass seed.	Clover-seed.	Salt.	Coal, bituminous.	Coal, anthracite.	Lime.	Hair.	Legislative enactments.
Arizona	60	56	32	45		54												60																	Compiled Laws, 1871.
California	60	54	32	50	40	52																													General Statutes, 1876.
Colorado	60	56	32	48	52	56	70	50			60			57			60						44		45	14		60		80		80			General Laws, 1877.
Columbia, Dist.	60	56	32			56		48			60																							Webb's Digest, 1868.
Connecticut	60	56	32	48	48	56		50			60		55	50	50	60	60	60																	General Statutes, 1875.
Dakota	60	56	32	48	42	56	70		20		60	46		52	60	60	60	60										60		80		80	80		Revised Code, 1877.
Delaware	60					56		d 44 / e 48														56												Revised Statutes, 1874.
Georgia	60	56	32	47	52	56	70	48	20		60	55		57	55		60	60		24	33		56	44		45	14		60			80	80	8	Act February 20, 1875.
Illinois	60	56	32	48	52	56	70	48	20	38	60	55		57	55		60			24	33	46	56	44		45	14		60	50 / c 55		80	80	8	Revised Statutes, 1874.
Indiana	60	56		48	50	56	68	50			60			48			60			25	33	46		44		45	14		60	50	h 80 / i 70				Revised Statutes, 1876.
Iowa	60	56	32	48	52	56	70		20		60	46		57			60		48	24	33	46	56	44	45	45	14	45	60	50		80	80		Revised Code, 1873; acts March 8, 1876; March 14, 1876.
Kansas	60	56	32	48	50	56	70	50	20	32	60	50		57	55		60			24	33	44	54	44	50	45	14	50	60	50		80	80	8	Gen. Stat., 1876; act March 2, 1876; March 10, 1877.
Kentucky	60	56	32	47	56	56	70	50	20		60	55		57	60		60	60		24	39	45	56	44	50	45	14	50	60	c 55		76	35	8	General Statutes, 1873.
Louisiana	60	32	32	32		56																													Revised Statutes, 1876.
Maine	60		30	48	48	56		50			60		50	52	50	60	64	60	44															11	Acts Jan. 25, 1871; Feb. 17, 1874.
Maryland	60	56	26	47	48	56						56																							Act Mar. 6, 1860; Apl. 1, 1872.
Massachusetts	60	56	32	48	48	56		50			60			52															70						General Statutes, 1860.
Michigan	60	56	32	48	48	56	70	50			60	56		54	58		60	60	48	22	28	46	56	44	50	45	14	50	60	56		80		70		Compiled Laws, 1872; act of April 20, 1877.

d Sifted. *e* Unsifted. *c* Fine. *h* Mined in the State. *i* Mined out of the State.

States and Territories.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Indian-corn.	Corn on cob.	Corn-meal and rye-meal.	Bran.	Malt.	Potatoes, Irish.	Potatoes, sweet.	Carrots.	Onions.	Turnips, English.	Beets.	Beans.	Pease.	Apples, Peaches, pears, and quinces.	Dried apples.	Dried peaches.	Castor-beans.	Flax-seed.	Hemp-seed.	Millet-seed.	Timothy-seed.	Blue-grass seed.	Hungarian-grass seed.	Clover-seed.	Salt.	Coal, bituminous.	Coal, anthracite.	Lime.	Hair.	Legislative enactments.
Minnesota	60	56	32	48	42	56					60																								Statutes at Large, 1873.
Missouri	60	56	32	48	52	56					60																								Gen. Stats., 1872; act Apl. 13, 1877.
Montana	60	56	35	48	52	56																													Codified Statutes, 1872.
Nebraska	60	56	34	48	52	56	70																												General Statutes, 1873.
New Hampshire	60	56	30			56																													Revised Statutes, 1867.
New Jersey	60	56	30	48	50	56																													Acts of Mar. 17, 1870; Mar. 25, 1872.
New York	60	56	32	48	48	58					60																								Revised Statutes, 1875.
Ohio	60	56	32	48	50	56	70				58	50		50																					Acts Mar. 21, 1863; Mar. 15, 1869; Apl. 29, 1872; Mar. 10, 1876.
Oregon	60	56	36	46	42	56					60																								General Laws, 1872.
Pennsylvania	60	56	30	47	48	56																													Digest of 1872.
Rhode Island		56	32	48		56					60																								General Statutes, 1872.
Vermont	60	56	32	48	46	56					60																								Rev. Stats., 1870; act Nov. 28, 1876.
Virginia	60	56	32	48	52	56	70																												Act March 20, 1877.
Washington	60	56	36	45	42	56																													Acts Jan'y 28, 1860; Jan. 29, 1863; Nov. 6, 1877.
West Virginia	60	56	32	48	52	56					60																								Revised Code, 1868.
Wisconsin	60	56	32	48	50	56	70				60																								Rev. Stats., 1871; acts Feb. 20, 1872; Mch. 20, 1873; Mch. 8, 1877.

a Course.	*b* Ground.	*c* Fine.	*f* Bituminous.	*g* Cannel.	

In addition to the articles named in the foregoing table, the following weights per bushel of the following articles are established by law in the States indicated, viz.:

Coke: Pennsylvania, 40 pounds to the bushel; Ohio, 40 pounds to the bushel; Iowa, 38 pounds to the bushel.
Hominy: Massachusetts, 50 pounds to the bushel; Ohio, 60 pounds to the bushel.
Pease, ground: Georgia, 25 pounds to the bushel; Kentucky, 24 pounds to the bushel.
Parsnips: Connecticut, 45 pounds to the bushel; Wisconsin, 44 pounds to the bushel; Montana, 50 pounds to the bushel.
Ruta-bagas: Maine, 60 pounds to the bushel; Connecticut, 60 pounds to the bushel; Wisconsin, 56 pounds to the bushel.
Mangel-wurzel: Maine, 60 pounds to the bushel; Connecticut, 60 pounds to the bushel; Washington Territory, 50 pounds to the bushel.
Vegetables, not specified: Rhode Island, 50 pounds to the bushel; Washington Territory, 50 pounds to the bushel.
Onion top sets: Virginia, 28 pounds to the bushel; Nebraska, 25 pounds to the bushel.
Dried fruit—Plums: Michigan, 28 pounds to the bushel.
Peaches, peeled: Virginia, 40 pounds to the bushel; Georgia, 38 pounds to the bushel.
Currants, gooseberries, and grapes: Iowa, 40 pounds to the bushel.
Other berries: Rhode Island, 32 pounds to the bushel; Michigan, 40 pounds to the bushel; Iowa, 32 pounds to the bushel.
Chestnuts: Virginia, 57 pounds to the bushel.
Peanuts: Virginia, 22 pounds to the bushel.
Seeds—Broom-corn: Iowa, 30 pounds to the bushel; Dakota, 30 pounds to the bushel.
Cotton: Georgia, 30 pounds to the bushel; Missouri, 33 pounds to the bushel.
Osage Orange; Virginia, 34 pounds to the bushel; Michigan, 33 pounds to the bushel; Iowa, 32 pounds to the bushel; Nebraska, 32 pounds to the bushel.
Rape: Wisconsin, 50 pounds to the bushel.
Sorghum: Iowa, 30 pounds to the bushel; Nebraska, 30 pounds to the bushel.
Orchard grass: Virginia, 14 pounds to the bushel; Michigan, 14 pounds to the bushel.
Redtop: Virginia, 12 pounds to the bushel; Michigan, 14 pounds to the bushel.
Sand: Iowa, 130 pounds to the bushel.

Letter of Dr. Franklin B. Hough, on State Legislation in regard to the Bushel.

A table similar to the foregoing was appended to the report of the Commissioner of Education, accompanying the response of the Secretary of the Interior to the resolution of the House of Representatives of Nov. 6, 1877, already mentioned. This table, prepared by Dr. Franklin B. Hough, Superintendent of the New York State census of 1865, embraces, with some difference of arrange-

ment, substantially the same facts as are contained in that above given, with the omission of those relating to Georgia and the District of Columbia. A letter to the commissioner from Dr. Hough, accompanying the table, presents so singular a picture of the inconsistent and often contradictory legislation of the different states in regard to this subject, that it is here reprinted, in order that we may do what lies in our power to diffuse among the people a knowledge of the extraordinary condition of things which it discloses, and so possibly contribute to the correction of these absurdities. Dr. Hough says: —

. . . I herewith submit a table of weights of a bushel of grain and other commodities, recently prepared by me for use in a work now in course of publication designed to facilitate the preservation of statistical records of farm industries. . . .

An examination of the table will show at a glance that while in some instances sufficient uniformity exists — as, for example, in the weight of wheat, which is sixty pounds to the bushel in every case where it is mentioned — yet that there is a singular discrepancy in other cases that might lead to serious misunderstanding in dealings between citizens of different states.

As an instance of this disparity, it may be noticed that one thousand bushels of barley, bought in the State of Kansas at forty-eight pounds to the bushel, would become one thousand five hundred bushels in New Orleans, where a contract for delivery would, in the absence of the agreement to the contrary, be satisfied at the rate of thirty-two pounds to the bushel.

In the case of rye, one thousand bushels would, by the same transfer, become one thousand seven hundred and fifty bushels; and in other cases differences might arise which, if not so great, are manifestly as unjust in the settlement of commercial accounts.

. . . Instances are not wanting of an exception to the rule in favor of certain counties, so that the statute weight of a bushel was not uniform at a given time throughout the state. An instance of this occurred in an act passed March 14, 1844, by the legislature of New Jersey, making a bushel of corn fifty-five pounds in Salem County, while it was fifty-six pounds in the rest of the state.

In one instance, an act now in force discriminates in favor of a commodity produced within the state as against the same brought from a neighboring state. This was by a law of Indiana, approved March 7, 1863, fixing the weight of a bushel of mineral coal at seventy pounds if mined within the state, and at eighty pounds if mined without and sold within the state.

As a general rule, these weights as fixed by law are declared to be intended as a standard of reference in the absence of an expressed agreement, but an instance may be cited in which this option of special contract is *forbidden*, and either one of the parties may obtain a forfeiture from the other, if he is

unwilling to accept the weight as fixed by law. I refer to the act of the Main[illegible] legislature of February 17, 1874, fixing the weight of a bushel of apples a[illegible] forty-four pounds, and forbidding agreement to the contrary, under a forfeitur[illegible] of twenty-five cents to each bushel. . . .

Custom has, in some markets, already fixed upon the *cental*, or one hun[illegible] dred pounds avoirdupois, as a unit in the sale of grains, and if this wer[illegible] adopted as the measure of all commodities mentioned in the table under con[illegible] sideration, there would be no difficulty in adjusting prices to this standard i[illegible] whatever might be bought and sold.

Referring back to the differences noticed in the weights of a bushel between different states, there can be no doubt but that an appeal to the courts of any one of the states would lead to a decision in accordance with the laws of that state in fixing the weight of a bushel of grain. It is further evident that decisions in state courts of last appeal might be as discordant upon this subject as the laws themselves.

But the Constitution of the United States provides that "full faith and credit shall be given in each state to the public acts, records, and judicial proceedings of every other state. And the Congress may by general law prescribe the manner in which such acts, records, and proceedings shall be proved, and the effect thereof."

It is easy to understand how the "manner of proof" might be provided for, much easier than to foresee in this instance "the effect thereof"; but should a case of difference between citizens of different states, arising from a misunderstanding on this subject, be brought for decision in the Supreme Court of the United States, it is evident that great difficulty would be experienced in giving that equal credit due to each state in its public acts and judicial decisions where each was equally positive and directly opposed to the other.

On carefully examining other statutes defining the weights and measures of quantities other than the bushel, we find differences between states that ought not to exist. The number of cubic inches in a struck bushel differs slightly, and the contents of a bushel of heaped measure considerably. The gallon of milk in Vermont and Massachusetts is two hundred and thirty-one cubic inches, or "wine measure," while in New Hampshire it is two hundred and eighty-two cubic inches, or "beer measure." The superficial area of a half-bushel (a matter of consequence in selling by heaped measure) is not uniform, and the contents of a barrel, as defined by state laws, is different in different states.

Extending these comparisons to other units of measure, we find notable discordance in the laws relating to the inspection of staves, lumber, shingles, and other forest products; differences that ought not to exist, and which are liable to lead to misunderstandings, by affording opportunities for fraud. The differences that exist between the inspection laws of the several states require a careful study before venturing upon general legislation, to the end that the true wants of the country and the equities of trade may be served without prejudice to any section or interest.

Section 6. — THE CHIEF EXECUTIVE OFFICERS OF THE GOVERNMENT UPON THE METRIC SYSTEM.

Synopsis of the responses of the Heads of Departments, Chiefs of Bureaus, and other Officers of the Executive Government of the United States, to the resolution of the House of Representatives of Nov. 6, 1877.

On the 6th of November, 1877, the following resolution was adopted by the House of Representatives: —

Resolved, That the heads of the executive departments of the government be, and they are hereby, requested to report to this House, at as early a date as practicable, what objections, if any, there are to making obligatory in all governmental transactions, the metrical system of weights and measures, whose use has been authorized in the United States by act of Congress, and also how long a preliminary notice should be given before such obligatory use can be introduced without detriment to the public service; and that they are also requested to state what objections there are, if any, to making the metrical system obligatory in all transactions between individuals, and what is the earliest date that can be set for the obligatory use of the metrical system throughout the United States.

The passage of this resolution forms an era in the legislation of this country on the subject of metrological reform. It is the first manifestation of a disposition on the part of our national legislature to take a positive forward step toward the creation of a rational system of weights and measures for the United States. The permissive acts of 1866 merely opened the way to such progress as might be possible without Congressional aid; this resolution gives evidence that Congress is at least not unwilling to promote the movement actively.

The responses therefore of the heads of the executive departments possess something more than an ephemeral interest. They will go upon the record as a part of permanent history. Under any circumstances they would attract attention, if only as the expression of the views of a number of intelligent gentlemen upon an important question dividing public opinion; but in the case which actually exists, they present themselves to us not as specula-

tive views merely, but as powerful influences; and the weight they carry with them is derived more from the commanding position than from the superior intelligence of their authors. This circumstance invests them with an adventitious potentiality for good or evil, which quite distracts our thoughts from what might otherwise be the interesting study of the various working of different minds upon a common problem, and fixes them upon the more serious question, what is to be the resultant effect of all these judicial deliverances upon the permanent welfare of our country.

Considerations of this kind justify us in giving a more careful consideration to these responses than they might otherwise have appeared to call for; and, in so far as they are unfavorable to the proposed reform, invite and even challenge us to examine the grounds on which objections rest. As it would transcend the limits we have proposed to ourselves to present the responses here in full, there has been attempted in the following pages a synopsis of the material substance of each, with such occasional observations interspersed as the object in view has seemed to require. As to the order of arrangement in which the communications from the several departments have been taken up, it is simply that in which the documents have happened to come to hand.

Department of State.

The metric system finds little favor at the hands of the chief cabinet minister. The Secretary tells us that so far as concerns the operations of his department, and especially its consular and commercial relations with foreign governments, the metric system, while of convenience and utility with respect to metric nations, would be of no benefit with regard to the non-metric, but would rather introduce detrimental confusion, in particular in commercial relations with Great Britain and other countries which have the same metrological systems as ours, "and with which countries the bulk of our foreign commerce is at present carried on." An examination of the statements in regard to our foreign commerce submitted to the committee simultaneously with this, will show that the Secretary is speaking here very loosely; since not more than half the total amount is with non-metric nations, and not

more than one-fourth is expressed in the denominations of a system identical with ours.

As to the length of time which would be necessary to bring the system into harmonious and uniform use in the department at home and in its dependencies abroad, provided it were made obligatory, the Secretary thinks that a preliminary notice of two years would suffice.

He hesitates to express an opinion as to the expediency of making the use of the system obligatory in transactions between individuals, the direct relations of the department with the people not being of a character to be either beneficially or injuriously affected by the proposed change. But he ventures to remind the committee that it is not easy to break up old traditions — that in countries where the metric system has been obligatory beyond the memory of the living generation — such, for example, as France — the old measures still linger, and defy complete eradication; and and that in other countries in which its introduction has been more recent — as in Spain — it has been practically disregarded by the people, and conformed to but partially by the government. These considerations are undeniably grave. The misfortune about them is, that they are arguments equally convincing to prove that it is not worth while in this world to attempt the reform of any traditional abuse.

In conclusion, the Department of State is on the whole "indisposed to recommend the obligatory use of the metrical system in all transactions between individuals;" but believes that if Congress should nevertheless make it so, "a period of not less than five years should be allowed to elapse before the act takes effect."

Department of the Treasury.

The Treasury Department is that which seems to have given to the questions proposed the largest consideration; and it is also that of which the replies, even when unfavorable, as they occasionally are, appear to be the most judicious. Several of the officers of the department were called upon by the Secretary to assist in preparing these replies; and their contributions appear in the communication of the chief to the committee, as independent responses, with the signatures of their authors attached.

THE SECRETARY'S VIEWS. — The Secretary himself, however, in transmitting these, takes occasion to express with great brevity his own opinions on the principal question involved; which he does by saying that he thinks it "not advisable to make the metrical system of weights and measures obligatory in any transactions at present." The reason for this conviction is, not that the new system would not be better, but that the old one "is so ingrafted upon the business habits of our fellow-citizens, that a new system should not be adopted until it is well understood and acquiesced in by the body of the people." This reminds us a little of the prudence of the sagacious individual mentioned by Hierocles, who resolved not to venture into the water until he had learned perfectly how to swim. The Secretary believes that the hasty adoption of the metric system would lead to "great confusion, many inconveniences and much litigation." He conceives nevertheless that "Congress might properly, in any revision of the tariff, adopt this system, stating in the law however the equivalents of the old in the metrical system;" but immediately after, to all intents and purposes, retracts this concession, by adding that "even this change would create some embarrassment, and is of doubtful utility."

This response of the Secretary himself, being in the nature of an opinion and not of an argument, presents no point on which issue may be joined. It is very well known, however, that there are many other men of judgment no less sound than that of the Secretary, and of experience in the practical affairs of business vastly greater than his can have been, who do *not* believe that the introduction of the metric system among us would produce either confusion or inconvenience or litigation to any serious extent; or that its obligatory use in the custom house would create embarrassment or fail to be of very large utility. As mere opinions these are worth perhaps as much as those of the official document before us — possibly more.

THE CHIEF CLERK. — Of the responses accompanying the Secretary's letter, the most extended and the most elaborate proceeds from the chief clerk of the department, Mr. J. K. Upton. Mr. Upton begins by describing the weights and measures in use at this time in this country, for which there is no authority except tradition. He observes that the Constitution has given to Congress

the power to fix standards for the measurement of length, weight, capacity, and value; but that this power has not been exercised by Congress, except so far as to declare that a certain brass weight procured in 1827 by the Minister of the United States at London, and now deposited in the mint of the United States, shall be the standard Troy pound of the mint — the same being identical with the Troy pound of England. Mr. Upton brings very clearly to light the imperfections of our system, by pointing out that in measuring lengths, there are employed twenty-five units, three of which, although under different names, have like values; while the others, having different names and values, bear no useful relation to each other. Also that in measuring weights, there are employed eighteen units, three of which are duplicated, while others have the same name, but are of different values. Those which are duplicated, he observes, to that extent reduce the number of units employed for different purposes; but the fact of their duplication confuses rather than simplifies the system. Also that in the measurement of capacity, there are employed twenty-seven units, though but nineteen have different names. None of these are duplicated, except in names; but the gallon has three different values, and so likewise has the quart and the pint. The bushel appears to have but one value; but in nearly every state, and in the customs-tariff of the United States, the term bushel is also employed as a unit of weight. The law fixes the number of pounds contained in a bushel according to the substance weighed. Mr. Upton appends to his response a table[1] showing the weight in pounds of the bushel for different commodities in different states; and according to this table it appears, that the number of commodities for which the law has established different weights per bushel in one state or another, is no less than fifty-six, while throughout this whole table there is but one commodity of any considerable importance, in regard to which the weight is quite uniform everywhere. That commodity is wheat,[2] of which the bushel, in every state where, so far as is known, there has been legislation on the subject, has been fixed at sixty pounds. In regard to the other very common products of the

[1] This table may be found at the end of Section 5 in this volume.

[2] *Peas* is another example, but is of secondary importance.

earth, there is in general no uniform standard universally prevailing, though in the case of rye and Indian corn there is a near approach to uniformity.

Even in contiguous states so small in territory as those of Massachusetts and Vermont, are found singular and unaccountable differences. In the first-named of these a bushel of oats is thirty-two pounds and in the second, thirty. Comparing the two states of New York and New Jersey, we find a bushel of Indian corn to be fifty-eight pounds in the first and fifty-six in the second. Also for New York a bushel of clover seed is sixty pounds and for New Jersey, sixty-four pounds; while for the same commodity Pennsylvania fixes the weight at sixty-two pounds. The confusion here illustrated is everywhere prevalent throughout the country. Trade being entirely free between the different states, no argument is necessary to show how great must be the inconvenience of having so common a standard as the bushel continually varying, as we pass from one state into another. But even in local transactions, or transactions within a single state, as Mr. Upton observes, one meets with Troy weights, apothecary's weights, and avoirdupois weights; with long tons, short tons, and ship tons; with wine gallons, beer gallons, and dry gallons; and with bushels of undefinable sizes, making an aggregate truly appalling.

The conclusion to which the writer is led by this survey is thus expressed: "A system consisting of a single unit for each measure, bearing similar relations to each other and having uniform subdivisions and multiples, would evidently be far superior for all purposes of measurements, local or throughout the states; and if superior for local and national use, it would also be preferable for international purposes, if, at the same time it should be in harmony with the systems of other countries."

Mr. Upton then proceeds to give an account of the metric system. Having stated its origin and its characteristics, he goes on to specify its advantages as compared with our existing system, which he finds to consist, first in its having an invariable standard of length taken from nature; second in its having a single unit of weight derived directly from that of length, and a single unit of capacity similarly derived for substances of all kinds wet or dry; thirdly in its having decimal subdivisions and multiples

Of its several units; fourthly in the uniformity, precision, and significancy of its nomenclature. All these advantages he pronounces real and substantial. But in regard to the first he questions whether the adoption of an invariable natural dimension as a standard is really of any great practical importance. The standard base of the metric system purports to be an aliquot part of the earth's polar circumference. Mr. Upton thinks that such a definite relation to the magnitude of the planet could be of no particular use, unless in its application to geography and astronomy. With regard to this he makes the somewhat unexpected statement that the division of the quadrant of the circle decimally into hundredths and thousandths has been found impracticable, and that the project has been abandoned; adding that to this extent the metric system has proved a failure. It is very much to be regretted that a paper, in other respects so sensible, should be disfigured by a remark like this. For nothing is better known to mathematicians, than that the division of the circle decimally is both practicable and advantageous, and is to a certain extent even now actually practised. The geodesists who conducted the great trigonometrical survey of the French meridian made use of decimal tables in their calculations during the later years of their work, and the reporter of the commission, the illustrious Delambre, pronounces such tables to be vastly more easy of use and more economical of labor than those founded on the sexagesimal division. That these tables are not in general use is only a consequence of the fact that the sexagesimal system was universal at the time when the metric system was established, so that subdivision of the circle decimally was not necessary to secure uniformity.

Mr. Upton proceeds further to state, that "recent experiments have demonstrated, that the length of the quadrant of the meridian was not accurately ascertained at the time of the adoption of the metric system, and consequently that the actual meter established is not the aliquot part of the meridian as supposed." The simple truth however is that no such demonstration has been made at all. What has been demonstrated as the result of the comparison of different meridian measurements is that the earth is not of an entirely regular figure; and therefore that when it is attempted to compute the length of the Paris meridian from the measurement of

the length of a meridian in Russia, or of a meridian in India, it is not probable that the result will correspond strictly with that which is obtained by direct measurement of the Paris meridian itself. It follows that the inferences of Bessel, de Schubert and Airey on this subject are not worthy to be compared at all with the actual measurement made by Delambre, Mechain, Borda, and the other great geodesists of France, who actually executed the French survey; and that it is vastly more likely that their actual measurement should be correct, than that a calculation based on the measurement of somebody else in India, or of somebody else in Russia, as to what it ought to be, should be so. It is time that the talk about *demonstration* in this matter should cease. Everything that has been said by everybody from Herschel downward on the subject of the error of the Paris meridian is utterly misleading, and wholly undeserving of serious consideration.[1]

Mr. Upton concludes, nevertheless, that the metric system, regardless of the presumed error of its base, is vastly superior to any other now existing, but he is yet of opinion that "to make its use obligatory by law for public purposes and in transactions between individuals, would be a harsh exercise of legislative authority." It might be inferred from this remark that Mr. Upton sees no essential difference between enforcing the use of the system "for public purposes," and "in transactions between individuals"; yet the great body of the friends of metric reform are in no hurry to insist on the use of the system in transactions between individuals; while they believe, on the other hand, that it would be, not only by no means a harsh exercise of authority, but even a salutary and beneficent one, to enforce it for public purposes.

Mr. Upton then gives a synopsis of legislation on this subject in other countries; showing the extent to which the system has already been adopted and made compulsory, the extent to which it has been legalized and made permissible, and finally also the extent to which it has not been legalized in either form, or introduced into use.[2] In view of these facts he concludes that "the metric system

[1] See letter to C. P. Culver, Clerk of the Committee of the House of Representatives, p. 255.

[2] This interesting portion of Mr. Upton's report will be found embodied in Section 2 in this volume.

is no longer an experiment," and that "its obligatory use in this country seems feasible," and is in his opinion desirable.

On the question of the time which ought to be allowed to elapse in order to prepare the government and the people for the exclusive use of the system, he expresses the belief that, for governmental transactions, a notice of two years would be sufficient; and for its general obligatory use in transactions between individuals, a notice of ten or fifteen years.

This reply, coming from the principal Bureau of that department of the government which is most largely concerned in transactions necessitating computations founded on units of weight and measure, is as favorable as could at this time be expected or probably desired. Those which accompany it are more brief, and are in general less encouraging.

THE SUPERINTENDENT OF THE COAST SURVEY. — The Chief of the Coast Survey, Com. C. P. Patterson, transmitting a report on the subject from Prof. J. E. Hilgard, Assistant Superintendent of the same work, says that he indorses the conclusions of Mr. Hilgard, which are in favor of a limited introduction of the system into the country, but suggests that no time ought to be now fixed for its introduction earlier than the year 1900. Com. Patterson thinks that no law on the subject should be passed without the most mature deliberation; and that such law when passed should not have compulsory effect until at least twenty-five years after the date of its passage. He thinks that in order to effect the change without shock to the people, and great loss to large investments, it would be for a long time necessary that all government and state departments should employ both systems, the present and the metric; and that active effort should be made in educational institutions, and through all channels by which the public attention can be reached, to acquaint the people thoroughly with the system, before its use should be made compulsory. He does not believe that any, or if any more than a few, adult persons now living, would ever become thoroughly familiar with the units of the metric system if introduced; and he thinks that the change, in a country like ours, having great commercial, agricultural, and manufacturing interests, would be vastly more difficult than among people whose business transactions are small. The commodore is further of

opinion that while the decimal system is for all scientific computations indispensable, there is yet room for question whether it is as convenient for ordinary uses in life as is the binary, which latter he calls the natural system, distinguishing the decimal as the artificial. He concludes that the only hope of a thorough change from our system to the metric is in education; and in the education not only of the present rising generation, but of that later one which is to come upon the stage after a law shall be adopted fixing the date at which the new system shall be compulsory.

THE ASSISTANT SUPERINTENDENT. — The report of Prof. Hilgard, transmitted by Com. Patterson, considers the question of the obligatory use of the metric measures, in reference to three heads.

First. — The operations of the Coast Survey.

Second. — The Bureaus of the Treasury Department generally.

Third. — The people at large.

In the Coast Survey, Prof. Hilgard says that the meter has always been used as the unit of measure from the beginning; but this is only in the geodetic operations, while in the hydrographic charts, the depths of water, or the soundings, are nevertheless expressed in feet and fathoms. "To have given," he remarks, "the depth of channels in the unfamiliar unit of meters, would have obviously destroyed the usefulness of the charts, and added another element of danger." This perhaps is true in regard to captains of vessels belonging to non-metric nations; but if so, our charts, in their present form, must add another element of danger in the case of seafarers from nearly all continental Europe. So long as we use feet and inches in ordinary business transactions, so long our coasting trade will require to be furnished with charts having the soundings in fathoms; but so soon as we shall have made the change from the present to the metric system, it will be as necessary to give the depths in meters for our sailors, as it is now necessary to do so for French sailors on the coast of France. In the interval of change the charts may require to have both kinds of measure given; since, as Com. Patterson observes, adults may but slowly adopt the metric units; but if we are never to adopt a desirable change in anything, for the reason that it will cost us a little trouble, the world is not likely hereafter to make much progress in any desirable direction. Mr. Hilgard suggests that in order to further the gradual adoption

of the metric units in navigation, two kinds of charts ought to be published, — one giving the soundings in fathoms and feet, and the other in meters and decimetres; so that the mariner or pilot may choose which he pleases.

In considering the case of the other Bureaus of the Treasury department, Mr. Hilgard speaks first of the coinage, and thinks that in this matter there could be no objection to making the exclusive use of the metric weights at once obligatory. In the operations of assaying, these weights have long been employed in the mint. Decimal weights are also in use there, and have always been so, in the transfer of bullion and coin, the Troy ounce being the unit. Hence so far as the decimal division is concerned, the introduction of metric weights would make no difference as respects facility. It would only change the unit of weight. He thinks, also, that there would be no just reason why those who deposit bullion for coinage, or any others who deal with the mint, should be unwilling to conform to any kind of weight the government might prescribe; because they are the beneficiaries and have no right to dictate in these matters. But in the custom house the case is different. Invoices received from metric nations accompanying importations are now stated in metric denominations; the others are mainly stated in our customary units, since the great bulk of them come from Great Britain or its dependencies; but in regard to these it is to be observed, that all the units of capacity in use with non-metric nations, even including those of Great Britain, are essentially different from ours, and incommensurable with them.

Since we have a law making the use of the metric weights and measures permissible, Mr. Hilgard thinks that their introduction into the custom house would require no further legislation, but that it might be effected by executive authority. He thinks it would be well that, if upon metric invoices duties should be assessed by the metric system, upon others they should continue to be assessed as at present; and adds the remark that though the permissive use of two different sets of units in assessing duties may appear to some minds objectionable as indicative of a want of system, there is nevertheless an inherent diversity in the case, which has to be met at one point or another; which fact may be illustrated by

saying, that it would be doubtless convenient that some custom-house officers should know the German and French languages as well as the English.

Mr. Hilgard seems to think that there is one difficulty in the way of instituting the practice of assessment upon metric units by executive authority, arising out of the law of 1866 which established certain legal equivalents between the principal units of the two systems, introducing fractions which would be troublesome in the endeavor to apply the provisions to our present tariff. But he is of opinion that Congress might agree to throw off these trivial fractions for the sake of simplification; and if, by doing so, a little advantage should be conceded to the importer, it would afford a stimulus to cupidity which would accelerate the introduction of the system.

Mr. Hilgard then proceeds to consider, whether any inconvenience to the public service would be likely to arise from the obligatory use of the metric system in the customs department; and expresses the opinion that the want of familiarity with the system on the part of the officers assessing the duties would make such inconvenience very serious. The efficiency of such an officer, he says, depends in the highest degree upon his familiarity with the values of the goods examined; and these are so associated in his mind with quantity, that he cannot separate the expression of measure from that of value. In regard to this it may be replied that for the merely arithmetical process of assessing duties, it is of no consequence what sort of system is used. Instead of pounds and gallons we might substitute *lumps* and *jugs;* and if the tariff stated that the commodity must be taxed so much per lump or so much per jug, and the invoice states the number of lumps or jugs in the importation, the determination of the duty, would be the simplest of all possible processes; although the officer might have no conception at all of the real amount or kind of the merchandise on which the duty was levied. It is therefore only in regard to the detection of fraud, that this want of familiarity would put the officer at a disadvantage. Mr. Hilgard says that, under the present system, the officer has in his mind some such idea as the following: "this silk is worth so much per yard," "this tea is worth so much per pound." It seems as if this difficulty might be got over very

easily by giving to the officer a little handbook in which tea at so much per pound is shown to be equivalent to tea at so much per kilogram, silk at so much per yard equivalent to silk at so much per meter, and so on. For a few days, or for a few weeks, perhaps, the officer would have to look at his book; but after that, any officer of ordinary common sense would be as familiar with one mode of estimating as with the other.

In view, however, of this difficulty, Mr. Hilgard thinks that the system should not be introduced into the custom house as obligatory until after an interval of at least twelve years. It is his opinion that in this case the argument previously used by him in favor of the immediate introduction of the system into the mint, does not hold; because, in respect to coinage, the individual is the beneficiary, but in the case of customs, it is the government which is the beneficiary. Nevertheless this argument does in a certain sense apply, for he has already suggested, that if, by throwing off fractions in the simplification of equivalents, we should make concessions favorable to the metric system, the individual would become the beneficiary, and would be stimulated by such advantage to prefer the metric duties.

The objections here raised to the early introduction of the system into the custom houses apply according to Mr. Hilgard with much greater force to taxation in the internal revenue department. He says, for instance, that in the assessments of taxes upon alcoholic spirits, the government, being the beneficiary, should not compel the people needlessly to use an unfamiliar way of making up their accounts. In the use of this work "needlessly" there is conveyed an idea of larger significancy, than probably the writer intended. If it is needless to require anybody to use the metric system, in the sense that nobody ever ought to be required to use it unless he is immediately and personally the gainer in the transaction in which he does so, then we might as well abandon any idea of ever extricating ourselves from our present metrological chaos; but if, at the cost of a temporary, and even a *very* temporary inconvenience indeed, the parties concerned, and the whole public with them, are to be subsequently gainers to a degree infinitely outweighing their momentary disadvantage, it would seem that there is no propriety in saying that such an incon-

venience is needless. Considering the interest of the public and of individuals in the largest way, to incur such inconvenience might really seem to be quite needful.

Mr. Hilgard further observes, that the experienced gauger has a check on his measures and calculations growing out of his familiarity with the sizes of casks, so that he can estimate their contents in gallons very nearly without measurement; but could not estimate them in *liters*. As to this it may be said that all such estimates must be exceedingly rough, so that no man can tell within a considerable limit of error the contents of a cask which he has not measured. But if he can guess pretty nearly in gallons, he can guess about as nearly in liters, since the liter exceeds a quart by only the twentieth part. On this point, finally, Mr. Hilgard remarks that while the objections to introducing the metric weights and measures into this branch of the public service are positive, on the other hand, the advantages to be derived from it are hardly assignable. The advocates of the measure, on the other hand, believe that a very important advantage would be derived from it at the present time, in the respect that its introduction would greatly aid in the education of the people to the use of a system by which they will ultimately be very greatly benefited.

Mr. Hilgard concludes, that the same interval ought to elapse before the calculation of internal revenue taxes should be attempted in accordance with the metric system, as he has before indicated in respect to the custom house.

In considering the question what are the objections to making the use of the metric system obligatory in transactions between individuals, Mr. Hilgard begins by saying that the committee in their question seem to take for granted what is not quite self-evident, that the adoption of the system *would* be an advantage. Without challenging the correctness of this assumption, however, he suggests that the grounds on which it rests, are only two, viz., first its inherent convenience; and, secondly, its probable prospective universality. The first of these points he regards as well taken, and too obvious for argument; as to the second, until recently he had been inclined to doubt; but the action of the German and Austro-Hungarian empires within the last six years seems to have settled the question. While the course of those great

powers was undecided, though the probabilities certainly were that some common system must ultimately become prevalent throughout the world, there was nothing absurd in the supposition that our own system might at length supplant the metric instead of being supplanted by it. For though it had been argued that the populations among whom the metric system had been established by law outnumbered largely those adhering to the old Anglo-Saxon measures, yet many of these millions which were counted on the metric side were mere herders and peasants using no measures at all; while among the non-metric nations manufactures and commerce were flourishing. Mr. Hilgard seems singularly to overlook the fact that most of the larger German states were fully committed to the metric system forty years ago, although they had not introduced it in full; and also that the Austrians had introduced it at a period almost as early into their custom houses. Of the non-metric nations he says that the United States, Great Britain and Russia have identical units of length and weight, while those of Germany and Austria now abolished were nearly the same and were called by the same names. These statements require some qualification. The United States, Great Britain and Russia have it is true a common foot measure; but none of the remaining dimensions of length in Russia correspond with ours. The Russian unit of weight is not at all like ours; neither is the Russian or the British unit of capacity. Moreover when it is observed that the units of Germany and Austria were nearly like ours, and were called by the same names, the implied and plausible argument that they might therefore easily be made identical and probably would be so in time, is not sustained by the history of the past; for every petty state and town of Germany has had its independent units, all approaching very nearly to each other, but all nevertheless preserved distinct for half a dozen centuries. The fact is that the assimilation of two systems of metrology closely approaching each other is not less difficult, and is even perhaps more so, than that of two others originally differing widely. If this were not the case we should encounter no difficulty now in assimilating our own system to the metric by shortening the foot nineteen hundredths of an inch, whereby it would become equal to thirty centimeters; but this change, to the opponents of reform, involves all the dreadful con-

sequences which are apprehended by them from the adoption of the meter.

As for those miserable herders and peasants of South America and elsewhere, of whom Mr. Hilgard thinks so meanly and who in his estimation do not count, it is quite worth while to remember that, count for as little as they may to-day, they are sure to count for very much to-morrow — and to count not merely as at present in the statistics of population, but still more in those of production and commerce. The wide expanse of territory, rich with every element of human wealth, over which they are now sparsely scattered, is destined to be filled up with swarming multitudes — multitudes made up no longer in the mass of ignorant herders and peasants only, but rather of intelligent farmers and mechanics, of miners and metallurgists, of manufacturers and merchant princes; and their vast contributions to the amount of the world's exchanges are likely to be such that even we ourselves may begin to count for little in the comparison. If, at this time, with — say one-half only — to put it moderately — of our foreign commerce conducted perforce in expressions of quantity with which we are wholly unfamiliar, we suffer so serious inconvenience, how can we justify ourselves in bequeathing unnecessarily to our descendants an inconvenience of the same kind tenfold or a hundredfold greater?

Regarding however the adhesion within the last few years of the great empires of Austria and Germany to the metric system as having definitely settled the metrological question for continental Europe, Mr. Hilgard thinks that, if our government would do its part in promoting the unification of weights and measures throughout the world, it can only do it by such legislation as may induce our people to adopt the same system spontaneously in their private transactions. He disapproves of coercive measures. The people should be led, not driven. He does not see how they could be driven. It is twelve years since the permissive use of the system was legalized among us. Our next step should be to introduce it by law into such governmental transactions as will not suffer by the sudden change of the habits of men. There, perhaps, he says legislation should stop for a time, until by zealous inculcation, by agitation, by instruction in all public schools, the new system shall have been voluntarily adopted by a great majority of the people,

when the enactment of an obligatory law will be only the consummation of an existing state of facts. "It has ever been the practice," he remarks, "of the Anglo-Saxon people to make laws in conformity with customs, and not to create customs by compulsory laws."

Mr. Hilgard then considers the question, how long it is likely to be, before the metric system will come naturally into so general use among our people, that no hardship will be felt from making it obligatory. It is his belief that this natural growth of the system upon the public favor will be very slow; and that the period of its general voluntary adoption could not be reasonably estimated at less than fifty years; but he thinks that the fixing of a time for its introduction so far in advance as the year 1900 would materially aid the growth; while the rest might be accomplished by, and must be left to, an active propaganda, on the part of the friends of the measure. It is his conviction that the impression which has been already made upon public opinion by the American Metric Bureau of Boston gives reason to think that we might not unwisely fix the last year of the century as the time when the law should make the system compulsory throughout the United States.

Mr. Hilgard concludes his response by mentioning the difficulties which most seriously impede the introduction into a country of varied mechanical industries like ours, of any new system of measures. Much of our American work which was formerly done by hand is now done by machinery. Great sums have been invested in the construction of the machinery used in our different industries. Millions of dollars would therefore be sunk, should it become suddenly necessary to replace these machines by others of entirely different and incommensurable dimensions. It is not denied, indeed, that the old dimensions might be adhered to, but called by metric names, putting the fractional number of meters or millimeters in place of dimensions now given in feet and inches. But this, in the view of Mr. Hilgard, would be an evasion, not a solution of the problem.

One point which it would have been quite in place to consider here we regret to find unnoticed, viz., the important relation which the system of measures employed in our workshops must have to the extension of our foreign trade in manufactured articles. Unless we

conform our measures to those in use abroad, we cannot expect to obtain a free sale for our locomotives, our sewing-machines, our steam-engines, our hand tools or machine tools, or even our locks and bolts, screws and hinges, and the endless detail of our minor hardware. Already we have a considerable foreign commerce in these things. Already some of our manufacturers use metric measures expressly for the foreign market. The Fairbanks Scale Co., the Waltham Watch Co., and doubtless many others, manufacture to metric dimensions for the sake of selling abroad. This consideration is one in which may be found ample justification for spending large sums in changing the present *plant* of American machine shops and foundries.

Another ground of objection to the change of our measures mentioned by Mr. Hilgard, and one which is of never-failing recurrence in the arguments of the opponents of the metric system, is that our real estate is divided according to a well known method, farms being laid out in acres and square chains, and town lots in feet and inches. Mr. Hilgard thinks that there is no adequate motive for changing these expressions into terms which must be necessarily fractional, and in which the foreign nations, whose convenience it is proposed to meet, have no conceivable interest. We might allow this to be true, and consent perhaps to leave the measurement of lands precisely where it is now; and yet, the argument in favor of the introduction of the metric system for all other purposes in life would remain as strong as ever. Neither Mr. Hilgard, nor anybody else, would defend the system of measuring land by chains and acres, on the ground that it is in harmonious relations with the system of measuring carpentry, flooring and plastering by the square foot or the square yard. Our land-measuring system is now an independent system, and if we should reform everything else, and leave that alone, we should have gained wherever we made a change, and lost nothing in what we left unchanged. In time no doubt it would be found preferable to measure land by hektars rather than by acres; but we may be content to wait for that.

The Chief Clerk of the Statistical Bureau. — The third reply from the Treasury Department proceeds from Mr. E. B. Elliott, Chief Clerk of the Bureau of Statistics. Mr. Elliott ex-

presses very directly and without circumlocution his opinion that the metric system of weights and measures ought to be made compulsory forthwith in certain governmental transactions, chiefly in those of an international character, such as concern the post-office, the coinage, and the customs; saying that the change might go into operation, without detriment to the public interests, with the fiscal year commencing July 1st, 1879. He thinks that the tariff schedule of common and metric equivalents should be prepared for this purpose in advance of the application; does not think it advisable to make the system immediately obligatory in transactions pertaining to the transfer of lands. to the collection of internal revenues, or the internal transactions of the government generally; nor would he consider it judicious to enforce it in the near future, in transactions between individuals in the ordinary business of private life. He thinks nevertheless it might be expedient to provide by law for its obligatory use upon the more extensive lines of railway communication of the country in regard to freight; and is inclined to leave the question of its introduction for local or domestic purposes generally, to the action of the several state legislatures.

Mr. Elliott concludes his communication by presenting extracts from the reports of the British Standards Commission, who, so long ago as in 1869, recommended that the metric system should be introduced into Great Britain for international purposes.

As to the suggestion that state legislation might provide for the obligatory use of the new system and determine the time of its introduction, there is the danger to be noted that this might lead to confusion, through the irregular and dissimilar action of different states; and therefore whatever legislation of this character should take place would come much more advantageously from the general government. State legislation, however, may aid very much the progress of the movement, by providing effectual means for diffusing a knowledge of the system and encouraging the people in its voluntary use. We have already seen in what manner legislatures may beneficially act in regard to this question, in the resolutions of the Legislature of Massachusetts, instructing the delegation in Congress from that state to forward by all means in their power the adoption of the metric system. We have seen

another example in the action of the Legislature of New Jersey, in the spring of 1878, making an appropriation for the purchase and distribution to the schools of the state, of complete sets of the weights and measures of the metric system, for use in instruction by the method of object teaching. And we have seen a third in the resolutions of the State of Connecticut of the much earlier date of 1864, calling on the superintendent of public instruction and upon the school boards in every district, to see that the metric system is taught to every child within the limits of the Commonwealth.

Department of War.

In transmitting reports from the chiefs of bureaus in his department responding to the interrogatories of the committee, the Secretary of War refrains from any expression of his own in regard to the matters in question. Of the papers transmitted, the first three are very brief and are not so much reports as apologies for not reporting. The Adjutant-General declines to express any opinion on the subject on the ground that the use of weights and measures is not a part of the business of his office, and that therefore he has not the requisite experience. The Inspector-General professes in like manner to have had no practical experience on which to found a judgment, yet delivers a judgment all the same, to the effect that "the compulsory change from the present system would be inexpedient, as involving a large outlay of money without adequate comparative results." The Judge Advocate General on the other hand is "impressed generally with the excellence of the French metric system, and with the desirableness of adopting a system on a decimal basis which shall be common to civilized nations;" but has "not such expert knowledge of the details or operation of the French system as to enable him to express an intelligent opinion thereon." The subject, he says, is without his official province.

The Quartermaster-General. — This officer replies, that if the law makes the use of the metric system obligatory in all government transactions, it can be adopted throughout the department under his direction within the space of one month from the time of the publication of the general orders on the subject; and if the

telegraph be used, within one week. He at the same time, however, very strenuously objects to the measure, for reasons which he states under four heads.

The first of these is that it will considerably increase the labor of computation, because sellers to the United States will make their deliveries in accordance with the measures now in general use, and the receiving officers will be obliged in the first instance to ascertain the amounts delivered by our ordinary weights and dimensions, and then to reduce these amounts, by the use of tables or otherwise, to the metric, in the statements of their vouchers, receipts, and accounts. All this appears to him to be a perfectly useless labor. It seems not to occur to him that the United States may easily require sellers to make their deliveries in accordance with metric measures; and that, as the seller is the beneficiary, it would, according to Mr. Hilgard, be quite right for the government to exact this. Hence the objection, so far as it relates to the increase of labor to the department, falls to the ground.

The second objection is, that since the reductions involve additional calculation, the transfer from one set of units to another unfamiliar and much less convenient will infallibly be the source of many mistakes and losses to the disbursing officers of the Treasury, and to the persons who sell supplies to the United States. This objection exists only as a consequence resulting from the preceding one, and therefore falls to the ground with it; but if such were not the case, it involves the assumption that the metric system is going to be always unfamiliar and inconvenient; whereas the practice of a very few weeks would make it perfectly familiar; and the very object of introducing the metric system is to secure greater convenience.

The third objection is that, in the operation of the new system, it will be necessary to abandon and sacrifice all the hay scales and other platform scales whose beams are now divided according to the American standard; also all rules and measures divided according to the yard, foot, and inch; also all the weights, pounds, ounces, or grains, avoirdupois, troy, or apothecaries, now in use; and to purchase and substitute in place of these, new scales and weights according to the metric system. There is force, no doubt, in this objection if the change is not worth making, or if it is not

worth what it will cost. But, on the contrary supposition, the expense, however we may regret its necessity, has nothing to do with the decision. It is presumable that the Quartermaster-General has often sanctioned, and has probably recommended, changes in the kind of vehicles, the style of tents, and many other portions of the vast variety of camp equipage furnished to our armies in the field, which have involved even in their minor details, much larger expenditure than would be necessary to buy out the whole stock of weights, measures, and balances now used in his department throughout the entire country.

It is moreover to be remembered that the heavy and costly articles of apparatus which he speaks of, such as hay scales and platform-scales, may be made to correspond to the metric system by merely changing their beams and without sacrificing the machinery itself or involving any great amount of outlay.

The fourth objection is, that if the metric system is introduced and made obligatory in government transactions and not in transactions between individuals, confusion and misunderstanding will result from the use of one standard on the part of the government and another on that of the people. This seems to be a reproduction in a new phase of the first objection. Men who sell to the government must conform to the government measures; and the very purpose of introducing the system first into government transactions is to bring men into necessary contact with the system through their dealings with the government, and so to force them to acquaint themselves with its advantages, while not requiring them to use it, otherwise than voluntarily, in their dealings with each other. The probability or rather the certainty is that instead of introducing confusion, the measure will serve as a beneficial educational instrumentality.

The propriety of making the system obligatory in transactions between individuals comes next under consideration; and as to this the Quartermaster-General expresses first his conviction that the thing is not within the power of Congress. He is not referring here to the constitutional power, of which there can be no doubt but of which he says nothing — he means to say simply and frankly that the people will never submit to it; that they will resist its enforcement; and probably, if worst comes to worst,

will overturn the government that attempts it. It will conflict, he says, if it can be enforced, as he is confident it cannot, great loss on many, especially on all manufacturers and mechanics whose shops are filled with costly tools, gauges, dies, and machinery constructed on the basis of the foot and inch. To alter all this machinery would be a work of years, and would cost millions of dollars. We seem to have heard something like this before.

But the Quartermaster-General proceeds to object to the system further, upon the ground that it is not a convenient one. Its measures are not of convenient length, whereas, the yard in his opinion is a convenient length. The yard and the goods measured by it can be halved, quartered, and subdivided into eighths, sixteenths, thirty-seconds, sixty-fourths, etc., or can, if we please, with equal facility be divided into tenths, hundredths, thousandths, and so on. It does not nevertheless appear from anything this officer states, that the meter is incapable of the same varieties of subdivision; notwithstanding which he goes on to assert that "half a meter is no dimension, half a centimeter is an unknown quantity; but half a yard, half a foot, half an inch, half a bushel, etc., are recognized." And he adds to this assertion the curious remark that "if half a liter, of a deciliter, or a quarter, eighth, or sixteenth of these quantities is provided for, then the metric decimal system is abandoned at once." The *decimal* system is, in this case, it is true, for the moment, abandoned — or rather it is supplemented by the addition of the binary — but not the *metric* system by any means, for the essence of the metric system is the meter. Moreover it had been heretofore supposed that fifty centimeters is half a meter; that five milimeters is half a centimeter; but according to this authority, we are not to be allowed to use these equivalent expressions, although we may be permitted to say half a foot, and half an inch.

The Quartermaster-General admits that the metric system applies admirably to money and to accounts of money; but adds that even here the government has been obliged to abandon, for the convenience of the people, the true, strict, decimal system, and to coin half-dollars, half-eagles, and so forth. This officer seems to entertain the singular notion that if we introduce a decimal system we shall not be permitted to divide by two; and yet all metric

nations do this, with no disparagement to the usefulness of their system.

The objector proceeds to state that even for the purpose of calculation, the metric system is not so advantageous or so practically useful, as our common system. "The unit," he says, "is too large, and the numbers produced and used in the calculations of the engineer, are tedious to write, and beyond the limits of ready comprehension." This is believed to be the first time an objection of this sort has been made to the metric system by a man of science.

Continuing his strictures the objector next informs the committee that "the true, natural, scientific basis of the metric system has been abandoned; that it was intended and enacted to be the ten millionth part of the quadrant of the Paris meridian; but that, in the progress of geodesic science, it has been ascertained that the standard meter bears no relation to that quadrant." This assertion, considering the quarter from which it comes, is very extraordinary. Nothing of the kind has been "ascertained." The natural basis of the metric system has not been "abandoned." When the question was before the International Commission for establishing a permanent International Bureau of Weights and Measures at their session of 1872, the criticisms of which we have heard so much upon the accuracy of the metric base, were treated as unworthy of consideration; and the commission resolved to adhere to the original prototype, deposited in 1799 in the Palace of the Archives in Paris. The names of Prof. Airey, Prof. Bessel and Gen. de Schubert are usually cited as authorities for the assertion that the length of the Paris meridian was never correctly ascertained; but the deductions of these mathematicians are derived from the combination of results obtained in the measurements of other meridians. Such deductions are, however, of no substantial value, since they depend upon the arbitrary hypothesis that the earth has a regular geometrical shape; and since the measurements so far made, when compared, serve to prove that this hypothesis is totally untenable. It follows that the closest probable approximation to the length of any meridian can only be derived from measurements made on that meridian itself. The operations of the commission of French geodesists who determined the length of

the Paris meridian were unquestionably as skilfully conducted as any that have ever been executed; and the results which they reached are more to be relied upon than the speculations of any mathematician however eminent, whose data are drawn from meridians measured in India or Russia or South America, or at the Cape of Good Hope. It happens, fortunately, moreover, that the portion of that meridian which the commission measured lies about equally on each side of the parallel of forty-five degrees, or in that part of the meridian where the uncertain ellipticity of the earth, considered as a spheroid, least affects the ultimate result, or where such uncertainty scarcely affects the result at all.

The variety of conclusions which may be arrived at, in the attempt to determine the true figure of the earth regarded as a regular spheroid, by the combination of measurements of different meridian arcs in different parts of the world, is almost unlimited.

Col. Everett, the accomplished director of the geodetic survey of India, the most extended survey of this kind ever executed, in the various combinations made by him to test this question, obtained no fewer than seventy-seven values for the eccentricity of geographical meridian. The probability therefore is that the length of the meter is as exactly ascertained as it is possible for science to ascertain it; or at any rate as it ever will be possible, until a survey can be extended over the whole length of the quadrant from the equator to the pole.

In view of this unquestionable truth, the following paragraph extracted from the document under consideration, must be regarded as one of the many curiosities of dogmatism which this discussion has elicited: —

> The fact is, that the meter is quite as arbitrary and unscientific a standard as the foot or yard. It is of less convenient length than either of them, and its compulsory adoption would derange the titles and records of every farm and of every city and village lot in the United States; would put every merchant, farmer, manufacturer, and mechanic to an unnecessary expense and trouble, and all, it seems to me, for the sake of indulging a fancy only, and a baseless fancy, of closet philosophers and mathematicians, for a scientific basis of measures and weights which (as the meter is not a ten millionth of the Paris quadrant, is not what it professes to be, and was enacted to be) cannot be found in the French metric system.

From this brief synopsis of the views of the Quartermaster-General we are not surprised to find him stating his conclusion in the following words: "I think that to make the French metric system obligatory between individuals in this country will be an impolitic and arbitrary interference with the rights, interests, habits, and customs of the people." We are tempted to inquire, Why say the *French* metric system? Why will it not suffice to say metric merely? It is truly noteworthy that the opponents of the system almost invariably endeavor to stigmatize it by speaking of it as French. It is French in so far as that the proposition to devise an improved system of weights and measures designed to be, as it is likely to become, international and universal, originated in France. But it is a matter of history that this metric system was the joint creation of an international commission, in which were represented no fewer than ten European powers; and therefore that to call it a French system, if not a result of imperfect information, can only be designed to enlist against it the prejudices of those who are really ill-informed.

The Surgeon-General.—The Chief of the medical staff of the army is no less unfriendly to the proposed reform than his brother officer whose views we have just been considering. He begins by presenting the objections, with which by much reiteration we have been made long since so familiar, to the introduction, because of the inconveniences that would follow of new measures; both as to the system of land division at present in use among us, and as to the substitution of tools and machinery gauged by a different standard from that now employed, for those actually used in the government workshops; but waiving the consideration of these difficulties as likely to be much more seriously felt in other departments of the government than in his own, he proceeds to enlarge upon what he regards as "the disastrous inconveniences which would result to the Medical Department of the Army from the measure in question." This measure, he says, "would compel the substitution of the metric system of weights and measures in prescribing and dispensing medicines in the army for the system of apothecaries' weights and measures at present in use by the entire medical profession of the United States; whereas, in all medical and surgical works of any importance printed in the

English language, doses are expressed in apothecaries' weights and measures only."

To compel medical officers to substitute metric weights and measures for these, would be to force them to make a laborious mathematical calculation every time they attempted to use the prescriptions or doses laid down in such medical works. "This thankless and unnecessary labor would waste," he says, "much time, and an error might cost life." He adds furthermore that "the strength of various medical tinctures and solutions in use in this country and in England, has been so adjusted that the proper dose is expressed in even minims, drachms, or fluid ounces; and that merely to substitute for these simple quantities the corresponding fractional numbers in the metric system would be a silly waste of labor." Finally "in order that the proper dose might be expressed in an even number of cubic centimeters, a revision of the Pharmacopœia would be necessary, and this would have to be followed by a similar revision of all the medical books in common use, before this new Pharmacopœia could itself be used."

To this very grave impeachment of the metric system considered in its applications to the practice of medicine, it is perhaps a sufficient answer to say, that a very large number of the more enlightened members of the medical profession in the great cities of the United States are known, and an overwhelming majority of them are believed, to be entirely in favor of the change proposed, and most heartily desirous to get rid of the absurd system of apothecaries' weight. Abundant evidence has been shown in Section Four of this supplement of the truth of this assertion. Many of the more prominent medical associations and many very eminent individual practitioners have already adopted the metric weights and measures, and are now actually using them. One cannot but be astonished at the discovery that the chief of the medical service of the army of the United States should be so profoundly ignorant of the far-reaching revolution which is thus going forward in his own profession, and as it would seem under his own eyes. If anything could be more astounding than this, it would be that, at the very time when these extraordinary dicta were uttered for the enlightenment of the Committee on Weights and Measures in the House of Representatives, the change so fraught

with danger, so pregnant of inevitable disaster, so deprecated for its folly and so dreaded for the load of useless labor it is destined to impose, had been already introduced and was actually in full operation in the coördinate branch of the public medical service carried on under the Treasury Department; and introduced by the order of the Surgeon-General superintending the Marine Hospitals of the United States, countersigned by the Secretary of the Treasury himself.

Up to this point the Surgeon-General confines himself to the inconveniences which his own branch of the public service will suffer, if compelled to use the new weights and measures. These having been disposed of, he proceeds to give his opinion of those which the general public will be compelled to endure, in case the use of such weights and measures should be made universally obligatory by law. The immediate consequence of such an enactment, in his opinion, would be, that inasmuch as the new weights, etc., are incommensurable with those now employed, long decimal fractions would become imperatively necessary in the most ordinary transactions of life. This observation furnishes an example of a curious confusion of thought which often betrays itself in the reasonings of the opponents of the metric system. They talk as if its introduction were to bring with it no change in the actual absolute dimensions of the things we deal with in our daily life; and that therefore, as these dimensions are not now expressed in whole numbers metrically, they must always continue to be expressed in troublesome fractions. The fact is, that with change of system the dimensions of familiar things will change correspondingly. The changes will of course be slight, almost in fact insensible; but they will be such, and will be intended to be such, as to eliminate fractions; yet even if this were not so, there would be no need to use long decimal fractions; since in ordinary transactions, no one expects to be, or if he did expect would find it possible to be, exact to the ten thousandth part of an inch or the one millionth part of a pound.

The Surgeon-General however, grave as are his apprehensions of trouble, inconvenience and confusion from the adoption of the metric system, expresses the rather singular opinion that this measure would be attended with less detriment to the public if the

system were to be made at once obligatory upon the whole people, than if its use were confined to governmental transactions. But whichever course is pursued, he sees nothing but detriment. He concludes by expressing the opinion, that the evil would be reduced to a minimum, if, by an international convention between the United States and Great Britain, a mutual agreement should be entered into to bring the system simultaneously into use among all English speaking peoples. He thinks that if the system has the great advantages claimed for it, it will come into use without further legislation; that if not, its forced introduction would be a great public wrong.

The Commissary-General. — This officer, like the last, views the proposed change with apprehension and distrust. In his view to make obligatory in government transactions the metric or any other system of weights and measures not already in use among the people, and consequently not familiar or generally understood, would be disadvantageous for a double reason; since it would not only involve great confusion, and great extra labor in making reductions from the system in use to that adopted for the government, but would have the more serious consequence of leading the people to look with grave suspicion upon government transactions, based as they would be upon a system of weights and measures they do not understand. He believes further that to adopt any system exclusively for the government would have a tendency to remove the government farther from the people, and to weaken if not nearly destroy their confidence in the integrity of the officials and in the agents of the executive departments.

It is not a little remarkable, and certainly it is amusing, to observe how many of these high functionaries of the government base their objections to the introduction of the metric system into the public service, upon the assumption that the people are to remain permanently ignorant of the system which it is proposed to introduce; and this too when the main object of such introduction is that of instructing these same people in the nature, the use and the practical advantages of that system. All these objections fall to the ground the moment it is assumed, on the other hand, that the people are not quite so stupid, and are not always going to be so ignorant, as these officials assume that they will be forever.

The Commissary-General proceeds to say that not only would it be very detrimental to the public interest to introduce the system into the government service exclusively, but that it would be inexpedient to make it obligatory between individuals, unless in coöperation with Great Britain, with whom we are so intimately connected by language, literature and commerce. He thinks that any change to a new system must necessarily require a great effort, and should therefore be preceded by a long period of preparation — say twenty years; — and that then, even though made with the most thorough preparation, it is destined inevitably to bring with it, "almost inextricable confusion, and well-nigh intolerable inconvenience."

The Paymaster-General. — The opinions of this officer are very concisely expressed, and are well considered and sensible. He believes that the eventual introduction of the metric system into common use in our country is highly desirable, and is fast becoming more and more necessary in our intercourse with foreign nations. In his opinion however, it would be advisable to begin only with legislation making the system obligatory in certain government transactions and not in all. Thus he would recommend its adoption in the collection of customs, in the postal system, in fixing the rates of coinage, and in all international transactions, from the first of July 1879; but he would not recommend it in the public land system, in purchases for the army and navy, or for government purposes generally, at so early a date. He thinks, that this partial legislation will stimulate the teaching of the system in all the schools; so that in six years the rising generation would be fully initiated into it, and accustomed to its use; after which it would be time enough to make it obligatory in all remaining governmental business. These measures, he believes, would prepare the people for the voluntary introduction of the system into domestic transactions; and if acquiesced in, for legislation making it obligatory; but thinks it desirable, that legislation of this character should not be premature, lest, by the creation of discontent, laws enacted in advance of public sentiment, should unfortunately be repealed. The gradual process, he thinks, will have the effect to make the use of the system finally acceptable to all the people of the United States.

THE CHIEF OF ENGINEERS. — The reply of this officer to the inquiries is very brief, and relates first to the adoption of the metric system in the government offices, and secondly, to the enforcement of its use in transactions between individuals. He says that, so far as the proposed change would affect the works conducted by officers of his corps, although any change in the ordinary and accepted methods must be really inconvenient, no reason other than this exists why it should not be made, provided always that time is given for preparation. He thinks the use of proposed metric standards exclusively should not be exacted in the office work of his branch of the service within a less interval of time than five years; fixing this limit as the minimum, in order to allow for the careful manufacture, comparison and distribution of the standards and their duplication in various forms for ordinary use; and also for the completion of the various necessary changes in the tables and formulæ. Such an interval appears to him to be also necessary in order that a practical familiarity with the new system may be acquired, as well by those not belonging to the public service with whom the business of the engineer department is transacted, as by the engineers themselves.

As to the compulsory use of the metric standards in private transactions, the opinion of the Chief Engineer, though not very strongly expressed, is clearly unfavorable. He sees nothing in the proposed change to affect advantageously the usual course of private business; and thinks that the demand for change does not come from business men, but from theorists, "in furtherance of a project designed for the general good in international intercourse." It is his view, therefore, that, inasmuch as the necessity for immediate change is not urgent, it will be better to make it only when it can be made by concerted and simultaneous action on the part of all English-speaking peoples. The relations of trade between this country and Great Britain appear to him to be such, that the adoption of a new standard of weights and measures by one of these two countries without concurrent action on the part of the other, would be extremely undesirable.

On the question whether it would be worth while to adopt a decimal system of metrology, or in other words to decimalize our own system if we refuse to accept the metric, he thinks but little

difference of opinion can exist; since such a change would simplify existing tables, and tend to a uniform practice throughout the world. He does not however, think such a proposed change to be a matter of immediate importance, or that such a change should be enforced upon individuals before it had become generally understood by being adopted in the government service and taught in all public schools.

THE CHIEF OF ORDNANCE. — The concluding response from the Department of War comes from the Chief of Ordnance, who, without any expression of his personal views, transmits a paper on the subject by Col. T. J. Treadwell of the Ordnance Bureau, with another from the Ordnance Board; merely stating his concurrence in the views and conclusions of these documents, and adding that he "anticipates little difficulty in the introduction of the metric system into all ordnance transactions, and deems twelve months' preliminary notice ample."

COL. TREADWELL'S VIEWS. — Col. Treadwell says that the change from the present system of weights and measures to the metric might be very simply made, by adopting a foot equal to three decimeters, which is less than our present foot by a very trifling fraction; and substituting nine decimeters for the yard. In all other respects, he would take the measures and their multiples and subdivisions from the metric system without change. His opinion is, that by retaining the names, *foot* and *yard*, while giving to them metric values, we shall make the change from the present to the new system with great facility and almost insensibly. He expresses confidently the belief that the use of the metric system would be of great practical value in the operations of the Ordnance Department, and is further convinced that "steps for its speedy introduction therein could be taken without delay." The Ordnance Board concurs with Col. Treadwell in these views, and especially in the opinion that the adoption of the proposed foot and yard would very much facilitate the conceptions of calculators and mechanics as to the values of the meter and its subdivisions in comparison with those of the English foot and yard.

The following observations of the Board are sensible and worthy of being quoted in full: —

> In the acquiring of a language, the old think in their own language and speak in the other; the young, however, with their comparatively blank and

highly impressible brains, harmonize thought and expression readily in acquiring a tongue.

The change from the unit of yards to one of meters, involving changes in weights and measures, and affecting every day all the barterings and the calculations of a great nation, is one which should have all the facilities available to ease the change.

As in language, the old will calculate in yards but work in meters.

If educated in youth, that high accord between the ideas of dimensions and the unit or parts of a unit to express them would exist, and no need of aids to help by reference to our present unit will be required for the coming man educated to the use of the metrical unit.

The retention of the idea of foot and yard seems to be important under this view of the case, and it was considered a judicious "aide memoire" to use a rule of that part of the meter-length which approximates the yard, graduated, however, with the metric subdivisions.

When questions arise involving large measurements, necessitating their expression in meters, they will be so noted; but as this latter measure conveys to the English mind (when these occasions arise) distances approximating to the same in yards, there is no reason for any special provision in this regard.

Decimeter-rules (three decimeters in length) are now in practical use in the United States.

Department of the Navy.

The Secretary's Views. — From the Navy Department, the resolution elicited but a single response which proceeds from the Secretary himself. The Secretary says, that the department in his charge perceives no objection to the compulsory introduction for government transactions, of the metric system of weights and measures, except in so far as it regards the soundings given on charts. He says, if it were made applicable to these, it would probably involve a total loss of all charts and chart-plates now in use; that the alteration of these would give them no increased value; and that so long as English charts continue to give depths in fathoms and feet, such alteration would be in fact prejudicial, and would prevent that free use and interchange of charts, which seems of essential importance to navigators. He adds, nevertheless, that so far as his department is concerned, no longer notice of the change would be necessary than might suffice to furnish the standard weights and measures adopted for government use. As to the remaining questions, which concern transactions between

individuals, and the earliest date at which the obligatory use of the system could be properly or conveniently enforced throughout the United States, the Secretary expresses his inability to answer, for want of information as to the course likely to be taken in regard to this matter by the other English speaking peoples. He thinks, that "however desirable or advantageous in theory the change might seem, yet if adopted by us, and not by the other peoples speaking the English language, it would seem probable that a mutual disadvantage would exist, growing out of diverse weights and measures."

This is evidently a question to which there are two sides. Such a mutual disadvantage already exists between ourselves and the nations of Continental Europe. The secretary apparently perceives this, and takes the precaution to fortify his opinion, by laying down the proposition as self-evident, that we shall suffer more by differing from the English, than by differing from the rest of mankind. His own words are "it may be assumed that a more general intercourse will exist between peoples speaking a common language, than between peoples who speak different languages." If by intercourse we are here to understand social intercourse, there is plausibility in this doctrine. But as commercial intercourse regards substantial pecuniary advantage much more than empty sentiment, and esteems common interest as of infinitely greater value than community of language, the secretary's argument seems to have little more than an imaginary basis. The argument is somewhat strengthened, when he refers to the present geographical distribution and extent of the countries in which the English language is used, and the large present importance of our commercial intercourse with those countries. But inasmuch as it seems to be eminently probable that large portions of the earth's surface now comparatively unimportant to the world's commerce are soon to come into active competition with those occupied by the English race, it is by no means safe to argue from what happens to be just now, to what is *going to be* hereafter. The probabilities are that, in the coming centuries, our commerce with the wonderfully rich and yet undeveloped provinces of South America, and even perhaps with those of Africa, will acquire an importance not inferior to that which springs from our present relations with Great Britain and her numerous dependencies.

Department of the Interior.

The Secretary of this department confines himself to the transmission of reports from heads of Bureaus, and from directors of the public surveys under the control of the department, without committing himself on any of the questions proposed in the resolution.

The Commissioner of the Land Office. — This officer points out with much particularity the objections to the introduction of metric measures into the land surveys of the United States. The case made by him in regard to lands already surveyed is pretty strong. It is not, however, by any means convincing, if it is designed to prove that the present system of land division is a good one; but it is very strong in showing the difficulty of displacing it by another. These public land surveys have been going on for a period of ninety years, and under them some seven million of acres lying in twenty-eight different states and territories, have been surveyed. Many of these millions remain yet unsold, and as the unsold lands are interspersed with those already disposed of, if the proposed obligatory law should be enacted, the department would be obliged to conduct its business upon two different systems, and its labor would accordingly be very much increased. The Commissioner proceeds to illustrate this inconvenience, by stating what numerical equivalents it would be necessary to use in place of the dimensions employed in the surveys at present, and shows that the areas of townships and the sides of sections and their contents would be expressible only in fractions; all of which is of course a necessary consequence of the incommensurability of the two systems, and has been often stated before. This nevertheless proves nothing as to the merit of the existing system, of which the best that can be said is that, so far as surveys under it have been actually completed, quantities are expressible without fractions. For it is very certain that nothing could be more absurd than the actual land unit — the acre. A unit of surface ought to be a square figure, having for its side a linear unit, or at least a whole number of linear units; but this is not true of the acre, although it is so of the square chain, which is a surveyor's unit, and is not recognized at all by farmers in the subdivisions of their lands.

The Commissioner does not deny that the application of the proposed system would greatly faciliate commercial operations, and more particularly those of the export trade; but he thinks that, even if introduced for such purposes, it ought not to be applied to the operations of his own branch of the service. Should, however, the proposed law be enacted without exempting his office from its operation, he is of opinion that a period of three years from the date of its passage ought to be allowed, in order that suitable preparations may be made to meet the demands of the new system.

The Commissioner of the Patent Office. — The report of this officer comes next in order. It informs us that, so far as the Patent Office is concerned, it is of no consequence what system of measure is used; but assuming that the Commissioner is desired to report as an expert on questions affecting the whole range of arts and sciences, it proceeds to treat the question as one of public concern, and entirely outside of the interest of this particular office.

In the first place, then, the Commissioner expresses the opinion that it was an unfortunate feature in the resolution to consider separately the interests of the government and those of the public generally. He says that the interests of the government and the people are so closely connected that they cannot be separated; that the dealings of the government in the purchase of supplies for the Army, Navy, Indian Bureau, and all other departments, are interminable; so that the use in commercial transactions of a particular system of weights and measures by the government, makes its use among the people unavoidable. The Commissioner here unconsciously founds his objection upon the very fact which induced the committee to give to their resolution the form which he disapproves. It is true that the government in buying and selling has to deal with the people; and it is precisely in this way that the government, when it adopts a new and improved system of metrology, is enabled to make itself a practical teacher of the system, and to accomplish its educational task in an entirely inoffensive way; for since in its dealings with the people, the people are benefited, the momentary and trivial inconvenience to which they may be subjected in the process, will be cheerfully acqui-

esced in for the sake of securing the benefit. The fact that this educational process will go on, the Commissioner, notwithstanding his objection to it, clearly perceives; for he says that, under its operation, the people will in time be led to make the use of the new system universal in transactions between individuals, as well as with the government; and that the abandonment of the old system, however popular, can be only a question of time. He even says that the plan to which he objects is in his opinion the only practicable means whereby the adoption of the new system by the people of the country could be accomplished; and in saying this he recognizes fully what the friends of this measure anticipate from it; that is, that the governmental use of the system will create in due time a popular use.

Of the practical advantages of the metric system he seems to have a very low opinion. He says that almost the sole advantage claimed for it, is the facility of calculation it affords in consequence of its decimal character; apparently therefore taking no account of the advantage which might arise from the existence of a uniform system of metrology throughout the world. But he denies that the decimal character of the system, useful as it may be in conducting arithmetical processes, is after all really advantageous on the whole; since the division into halves and quarters, which has been found indispensable in our coinage, is the natural division, is more readily grasped by the mind, and, in its subdivisions, is more readily appreciated, than division by tens, hundreds and thousands.

If it were inevitable that the adoption of a decimal system must exclude the binary, as the opponents of the metric system so often argue, this reasoning might be entitled to some consideration; but the very example cited of our own coinage proves that this is not so. We have half dollars and quarter dollars as well as dimes. We have half dimes also, and we once had a half cent which would still be coined if it had not been found too small in value for any important use. The French coin the half franc and also use the half kilogram, and the half liter. There is no people employing the metric system, which does not also employ the binary divisions. The halves and quarters of the larger metric denominations are always expressible in whole numbers of lower

denominations. The French say half a franc and fifty centimes, half a centimeter and five millimeters, etc. interchangeably. No confusion or inconvenience arises from this.

The inconvenience of changing our long established system of land measurement is next presented by the Commissioner, who repeats of course the objections which have been previously presented by the Commissioner of the Land Office. He gives however an interesting illustration of the difficulty attending this change, and the tenacity with which men adhere to established usages in these matters, drawn from experience within a limited district in our own country. To this day, he says, the common unit of land measurement in the vicinity of St. Louis, Mo., is the "arpent," which is somewhat less than an acre, and was introduced there by the early French settlers. The territory, the Commissioner informs us, has since their day passed from French into Spanish hands, and from the Spanish into ours. It has been nearly three-fourths of a century American soil; the French settlers have become merged with immigrants from the east and from Europe; old customs have disappeared, and the few lingering remains of the French occupation are cherished by antiquarians, with almost as much tenderness as if they were relics of Assyria or Babylon; yet, to-day, there is scarcely a piece of real estate in the vicinity of St. Louis that is not measured in arpents. It is so advertised, and so sold; and this word lingers in the speech of the people, and the idea it indicates lingers in their daily transactions, with a tenacity that nothing appears to shake. There being no peculiar quality about the arpent to make it a more convenient unit for measurement than the acre, its retention is something more than the result of habit. It is because all real estate transactions are matters of permanent record, and permanent records are changed only with great difficulty.

With reference to this we may remark, as we have done before, that it is by no means indispensable that land measurements should change if we introduce the metric system. Remaining as they are, they will be very little more discordant with the metric, than they are now with our ordinary system of measurement in feet and inches.

To the question how long a time should be allowed, supposing

that Congress should determine on the change, before the substitution of the new system of weights and measures in the households and workshops of the people should take place, the Commissioner replies, that inasmuch as the expense of procuring new instruments of measurement and weight would be serious, an interval of ten years might perhaps be advisable, but that at least five years should be permitted to elapse before the change should be made definite.

The Commissioner of Education. — From this officer we have a response of some length. But as he does not answer the questions of the resolution, his communication requires but a brief notice. He merely expresses the opinion that no greater difficulty or delay need be apprehended in substituting the metric weights and measures for those now in general use, than was experienced in the adoption of the gram as the unit of weight of the International Postal Union. But instead of either suggesting objections to the proposed change, or arguments in favor of it, he contents himself with indicating the transactions in the several governmental departments which the change will affect, and states the metric equivalents which will have to be substituted for the values now employed.

In the concluding part of this communication it is suggested that the reform of our metrological system may be effected in either of three ways, viz., first, by adopting, as the resolution proposes, the metric system itself; secondly, by retaining the standards now in use, the yard, the gallon, the bushel, the mile, etc., with such slight modifications as shall make them metric and easily convertible into corresponding metric units;[1] and thirdly by preserving our present units unaltered, as the yard, the gallon, the bushel, the pound, and the acre, but forming upon them, by decimal multiplication and division, a more convenient series of derivative weights and measures than we have at present. This latter alternative, which with many opponents of the metric system is popular, would however subject the people to about as great

[1] This suggestion which is substantially that of Major Treadwell previously noticed, the Commissioner says accords with what has been done by the German Empire, a statement which should rather have been made of several of the constituent states of the empire before the union, the empire having adopted the metric system in full.

an amount of temporary inconvenience, as the adoption of the metric system itself; and it will probably never be accepted. The expedient was tried by Sweden and Denmark; but in the former country it has already given away to the metric system, and probably soon will do so in the latter.

The Commissioner points out, finally, a variety of modes in which the Federal government can assist in acquainting the people with the metric system, before requiring its exclusive use. These are to introduce metric instruments into all the departmental and other offices; to construct maps, charts and diagrams to metric scales; to employ the system in governmental purchases, surveys and sales; to make use of its denominations in all governmental publications, and to require a thorough acquaintance with it, on the part of candidates for admission to the medical, military, naval and civil service.

Some simple expedients are suggested, by way of illustration, for keeping the metric dimensions constantly before the people; such as requiring writing paper to be supplied in reams of five hundred sheets instead of four hundred and eighty; expressing the weight per ream in kilograms rather than in pounds; and making the rulings for ordinary styles one centimeter apart. Also providing that paper and official envelopes, and moreover all envelopes furnished to the public by the Post-Office department, should have a decimeter scale printed upon them divided into centimeters and millimeters; that ink and mucilage should be ordered in bottles holding a liter instead of a quart; that the millimetric barometer should take the place of the present one, and so on. Appended to this paper is a table prepared by Dr. Franklin B. Hough, former superintendent of the New York state census, showing the varieties of bushel-weights prescribed by law in different states for various commodities — a table similar to that furnished by Mr. Upton already referred to — and accompanied by a letter from Dr. Hough, giving many curious examples of the confusion prevailing in our country in regard to these measures. This very interesting and instructive letter may be found reprinted in this supplement, at the close of Section 5.

The Director of the Surveys of the Territories. — The response of Dr. F. V. Hayden, Director of the Geological and Geographical Surveys of the territories, is brief but favorable.

He says that "among the majority of scientific men in all countries, a uniform system of weights and measures for the entire civilized world is held as a matter of the highest importance;" and quotes the sentiment of John Quincy Adams, in his famous report upon this subject, that "if there existed upon earth a combination of power and will adequate to accomplish the result [the unification of weights and measures] by the energy of a single act, the being who should exercise it, would be among the greatest of benefactors to the human race."

Dr. Hayden however thinks that it would be impossible to make the metric system compulsory during the present generation; that it ought to be introduced into our common schools to the exclusion of our English method; and that "all objections to the system will probably be overcome entirely, in the progress of time."

The Director of the Surveys of the Territories — Second Division. — The reply of Major Powell is more extended than that of Dr. Hayden and deals with the subject in a remarkably sensible way. He says that "while there can be no doubt that very great advantages would be secured by the adoption of the system, no small amount of inconvenience would nevertheless be incurred in making the transition; and therefore that the question is resolved into the ulterior one, whether the advantages to be secured would more than compensate for the difficulties which will have to be encountered before the system is thoroughly engrafted upon the habits of the people." He further says that if, when the committee inquire what are the objections to the proposed measure they refer to insuperable objections, he can only reply that he sees none of that character. On the other hand, he thinks it worth the attention of the committee that a very large number of our people, embracing probably a great majority of all the citizens of the United States, are already fully informed on the subject, and deem the proposed change of system wise. He would therefore recommend its introduction into some departments of the government service at an early date. As it is already taught in very many schools both public and private, the method of determining in the new units quantities expressed in the old, is familiar to the youth of the country, and for them the transition from one to the other will be a comparatively easy matter.

Major Powell thinks that the prevailing interest in this subject should be stimulated by all judicious measures; and that among such would be the adoption of the system in international commerce, in the postal service, and in that portion of the business of the general land office which relates to the public lands yet unsurveyed. Differing from some of the other gentlemen whose opinions on the subject have been examined, he thinks that such adoption of the system by the government will not occasion serious inconvenience to private individuals transacting business with the government. At the same time it is his opinion that abrupt and sweeping legislative measures might have the unfortunate effect to check the growing interest in the reform, by precipitating at once upon the people all the difficulties inevitable to the transition; a result which might indefinitely postpone the accomplishment of this great good. As to the question of the internal revenue service, he thinks it would be wise to wait until the result of experience in the custom house has been ascertained. All the governmental changes suggested he thinks may be accomplished within a year; but a much longer time would be necessary to the successful introduction of the system by legislative measures into individual transactions. Differing again from some other officers whose opinions have been noticed, he thinks that the substitution of the metric for the present measures in transactions relating to land, will but slightly inconvenience the people at large; for the reason that "the measurement of land is practically relegated to skilled persons, as engineers and surveyors, and the conveyancing of land to persons skilled in that branch of business." It would not in his opinion be well, at present, to fix any definite period for making the new system obligatory between individuals; but he believes that this must ultimately be done, notwithstanding the inconvenience the change may bring; an inconvenience, he says, which is obviously "a part of the price the government and the people will be compelled to pay for the ultimate accomplishment of a good work."

Department of the Post Office.

The Postmaster-General himself furnishes the sole response to the resolution from this department. Two objections only, he

says, occur to him to the proposition to make the use of the metric system of weights and measures obligatory throughout the domestic postal service; and these are, first, the expense incidental to the change; and secondly, "the apprehension that the practical workings of the new system would fail to give satisfaction, owing to a lack of knowledge of the metric system, and of experience in its use and application on the part of a great many postmasters, especially at the small post-offices, and of the public at large." Singularly enough, the Postmaster-General makes no allusion to the law adopted twelve years ago, which made it implicitly the duty of his department to introduce the metric weights into all the post-offices, so soon as it could be conveniently done. During these twelve years the law has been wholly inoperative so far as our domestic service is concerned, although one Postmaster-General some years ago, went so far as to call on the Bureau of Weights and Measures for designs of metric balances proper for this service, which designs were furnished him. The Bureau at the same time estimated the probable cost of the change at no more than twenty thousand dollars for the entire country. The difficulty which the Postmaster-General apprehends as likely to arise out of a want of knowledge and experience on the part of the petty postmasters, is not easy to understand. Postmasters reckon the rates of postage according to postal units, which units are represented to them by pieces of metal of whose particular absolute weight it is of no consequence whatever that they should know the value. The use of the metric system in post-offices practically involves no processes, and no calculations, differing in the slightest degree from those which are used now. The whole change consists in the change of a few words. As to expense, the document under consideration submits an estimate from the well-known manufacturers of balances, Messrs. Fairbanks & Co., by whom the post-office balances actually in use are furnished; which sets down the total sum necessary to provide new balances at one hundred and sixty-six thousand dollars, subject to a reduction for cash payment of twenty-five per cent., making the actual cost to the government about one hundred and twenty-five thousand dollars. No account is taken of the value of the present balances, which, it seems to be assumed, are to be entirely sacrificed. There can be

little doubt, nevertheless, that they are worth something, if not more than half or a quarter of their cost price.

The Postmaster-General transmits certain correspondence on this subject of cost, particularly a letter from Fairbanks & Co., dated as far back as July 15, 1874, wherein is asserted the impracticability of making the present letter balances serviceable, by attaching to them new beams divided to metric weights, or of adapting the old beams to the new service by modifying the running weights now employed. It may nevertheless be safely affirmed that neither the one nor the other of these expedients is at all impracticable. Either of them would be very easy to a willing mind. But it is intelligible enough that the manufacturer who wishes to sell one hundred and fifty thousand dollars' worth of balances, would not easily discover the practicability of an expedient which would deprive him of his bargain.

In conclusion, the Postmaster-General expresses the opinion that no great inherent difficulty is to be encountered in the application of the metric system to the transactions of the domestic postal service; and adds that it is certainly a simpler system than the one in use, and that it has for some time past been actually employed by the department for the foreign mail service. His only objection apart from expense therefore, is founded on the fear of mistakes and consequently resulting annoyances, and possible losses; and not on any well founded objection to the principle of the system. The ground of apprehension, he thinks, will be greatly lessened if not altogether removed, provided sufficient time be given to familiarize the postmasters and the general public with the workings of the new system before discontinuing the old one. He therefore suggests that if Congress should decide to extend the use of the metric system to the entire postal service of the country, an adequate appropriation should be made to supply all the post-offices in the United States with balances and weights of that system; and that then, after such supply is completed, a certain time, say six months, should be allowed, before requiring their obligatory use. Twelve months he thinks would be ample time to supply the offices; and eighteen months after the appropriation is available, would be a proper time for putting the new system into operation.

At the date of the Postmaster-General's letter, Nov. 19, 1877,

the number of post-offices in the United States was thirty-seven thousand five hundred and seventy-five, with an annual increase of one thousand.

FEBRUARY, 1879. — As these sheets are going to press, the report of the Committee of the House, prepared in view of all the official utterances above examined, comes to hand. Its tone is eminently cheering; and a circumstance attending it which is more cheering still is the fact that it is entirely unanimous. The latter portion is so clear, positive, and emphatic that we cannot refrain from giving it insertion here. The committee say: —

> The grand object of this metrological reform may be stated in three words: 1. *Uniformity;* 2. *Permanency;* and 3. *Universality* — one standard of weights and measures for all persons and for all purposes, and to continue the same for all time to come.
>
> The nomenclature of the metric system we consider is not only unrivalled in respect to precision, significance, brevity, and completeness, but being derived from two ancient classic languages, it becomes cosmopolitan in character. As soon as the values of the four base units are fixed in the mind, the values of all the *derivative units*, being formed by *multiplying* or *dividing* the *base* by *ten*, are at once apprehended.
>
> From the survey we have been able to make of the more recent progress of this metrological reform in the more civilized and enlightened portions of the globe, we are irresistibly led to the conclusion that the metric system of weights and measures is destined to become in the near future obligatory among all the civilized nations of the world. Its adoption in the United States, and its obligatory use in all the government departments, is believed to be by many a fixed fact at no very distant day. As an earnest of this fact, we call your attention to the accompanying reports of the several heads of the executive departments of the government, as to the periods of time at which it would be advisable to adopt the system in their several bureaus.
>
> Why, then, we would most respectfully inquire, should this country longer remain indifferent to its adoption, when our commercial relations with France, the Germanic Empire, Portugal, Belgium, Holland, Spain, Italy, Austria, Turkey, Sweden, Romania, Moldavia, Wallachia, Switzerland, Denmark, Greece, Mexico, and the South American States, and their dependencies or colonies, that have already made the metric system obligatory, using no other, render it necessary in our intercourse with these nations to use this system in all our sales and purchases? The magnitude of these transactions in commerce, and the intimate social relations between these people and the

United States, combine to render the early adoption of the system in this country imperative.

Quite fifty years ago, when this system of metrology was struggling for existence in the country which gave it birth, John Quincy Adams said of it: "The French system embraces all the great and important principles of uniformity which can be applied to weights and measures. . . . It is a system adapted by the highest effort of human science, ingenuity, and skill, to the common purposes of all. Considered merely as a labor-saving machine, it is a new power offered to man, incomparably greater than that which he has acquired by the agency which he has given to steam. It is in design the greatest *invention* of human ingenuity since that of printing. . . . Its universal establishment would be a universal blessing."

Indeed, the metric system has received the support of statesmen and the earnest sanction of scientists both in the New and the Old World for the past half century or more; and we cannot therefore longer treat with indifference the numerous appeals that are being made to Congress, from time to time, by the scientific and business men of the country, urging the adoption of the system in such departments of the government, at least, as have the largest relations with those countries and nations which have already adopted it in whole or in part, as an earnest of our purpose to adopt it in whole in all government transactions, so soon as our people are educated up to that point in its use that they will prefer the new to the existing system.

At the last session of Congress upwards of $17,000 was appropriated for rent of buildings for the safe-keeping and preservation of finished weights, measures, balances, and metric standards, and to meet treaty obligations arising from a convention for the establishment and maintenance of an international bureau of weights and measures at or near Paris, France; and further, to utilize the standard metric weights and measures furnished the several states, by act of Congress, and which must prove entirely useless to them, unless the system is made obligatory in some form and to some certain extent in such of the government departments having constant or daily relations with the states and their peoples, that they may be brought into daily use; and to secure this desirable end your committee would earnestly recommend the early passage of House bill No. 2699, introduced at the last session of this Congress, to wit:

Mr. MAISH, by unanimous consent, introduced the following bill: —

A BILL to establish the metric system in the post-offices and custom-houses of the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That on and after July first, eighteen hundred and eighty, for all postal purposes, fifteen grams shall be substituted for half an ounce, and so on in progression.

SEC. 2. That on or before July first, eighteen hundred and eighty, the Post-

master-General shall furnish all post-offices with postal balances denominated in grams of the metric system, at an expense not exceeding fifty thousand dollars, which sum is hereby appropriated, or so much thereof as may be necessary for this purpose.

SEC. 3. That on and after July first, eighteen hundred and eighty, the metric system of weights and measures, as legalized in section thirty-five hundred and sixty-nine of the Revised Statutes, shall be obligatory in the assessment of duties on imported commodities in the custom-houses of the United States."

Unfortunately this important report was not presented until near the close of the last session of an expiring Congress, when it was quite too late to secure a test vote upon the measures recommended, or even to bring the subject before the House for discussion. But the labor of the committee has not on that account been by any means lost. It will aid very much in diffusing information on the subject, and in informing the Congressional mind, no less than that of the general public, in regard to it. Moreover, by arousing public attention, it will make men who have been hitherto indifferent, cognizant of a drift of public opinion of which they had been previously unconscious, and by which they have consequently remained uninfluenced. But the effect of greatest moment after all which it will carry with it, will be that of familiarizing men's minds with the idea that something has got to be done about this matter, and done very soon. We have arrived at the parting of the roads. We cannot and must not stand hesitating there forever.

ADDENDUM TO SECTION FOUR.

FURTHER PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

At a meeting of the National Academy of Sciences, held at Washington, D. C., on Friday, April 18, 1879, the following report, with accompanying resolutions, from the committee of the Academy on Weights, Measures and Coinage, was presented. The resolutions were read, discussed and adopted. The reading of the report in the business meeting was dispensed with, for want of time; and an order was taken that the report be publicly read in the succeeding scientific meeting, which was accordingly done. The resolutions received the unanimous concurrence of the members of the committee, with the exception of one, viz., Gen. M. C. Meigs, who dissented, and asked that his dissent should be entered on the minutes. The report was not adopted by the Academy, but as it summarizes concisely the principal facts connected with the recent progress of the movement in favor of metrological reform in the U. S., it is believed to be of sufficient interest to merit insertion here.

REPORT.

To the National Academy of Sciences: —

The Committee on Weights, Measures and Coinage beg leave to report as follows: —

Under the constitution of the United States, Congress is empowered to coin money and regulate the value thereof, and to fix the standard of weights and measures. So far as weights and measures are concerned, this authority has never been exercised by any direct acts of positive legislation. The weights and measures at present in use in the United States were originally derived from Great Britain during the colonial period, and in some of the colonies were sanctioned by acts of the colonial legislatures.

After the adoption of the constitution, and the establishment of a central federal government, the want of uniformity among the standards of weight and measure in different parts of the country, was found to be attended with serious inconvenience in the assessment and collection of duties in the custom houses; and in consequence of this, an order was issued in the year 1830, by the secre-

tary of the treasury under authority of a resolution of the senate, requiring from the chief of the coast survey a report on these diversities, with instructions also to prepare standard measures to which all the custom houses should be required to conform.

By an act of congress passed in 1837, it was provided that copies of these standards should be furnished to the executive authorities of the several states of the Union.

Though the effect of these measures of executive and legislative action was to perpetuate and fasten upon the country for a long period, a metrological system in many respects faulty, they were attended with the advantage of reducing to uniformity the weights in use throughout our country, and to a certain extent the measures also. But the system itself has never been satisfactory to our people, and from the foundation of the government there have been constantly recurring demands for its reform. These demands, during the past twenty years, have been growing more and more urgent, having been stimulated not only by a sense of the disadvantages of the system by which we are burdened, but also by the observation of the reforms which have been in the mean time going forward in these matters, throughout a very large extent of the civilized world.

It is now about sixteen years since the subject was brought to the attention of this Academy, by a communication from the secretary of the treasury, at that time Mr. Chase. Assuming some reform of our metrological system to be necessary, the secretary desired the opinion of the Academy as to the principles which should govern the attempt to effect such reform. A committee was appointed to consider this question, and the same committee has been continued down to the present time.

It was not until January 1866, that the committee made a report. In this report, the committee declared themselves in favor of the decimal principle of division, and of the metric system as being a decimal system already extensively in use. They "therefore suggest that the Academy recommend to congress to authorize and encourage by law the introduction and use of the metrical system of weights and measures; and that with a view to familiarize the people with the system, the Academy recommend that provision be made by law for the manufacture and distribution to the custom

houses and states, of metrical standards of weights and measures; to introduce the system into the post offices by making a single letter weigh fifteen grams instead of fourteen and seventeen hundredths, or half an ounce; and to cause the new cent and two-cent pieces to be so coined that they shall weigh, respectively five and ten grams, and that their diameters shall be made to bear a determinate and simple ratio to the metrical unit of length."

This report was communicated to congress by the president of the Academy, and was received with an unexpected degree of favor. The earliest evidence of this appeared in the month of May following, in the passage of an act directing the coinage of a five-cent piece of nickel weighing five grams; the dimensions being left to the director of the mint who caused it to be struck of the diameter of two centimeters.

In July following was passed an act authorizing and directing the secretary of the treasury "to furnish to each state, to be delivered to the governor thereof, one set of the standard weights and measures of the metric system for the use of the states respectively." Almost simultaneously with this, a second act was passed, making the use of the metric denominations of weight and measure legal in all contracts; and also a third one, making fifteen grams the unit of postal weight for the assessment of charges upon matter passing through the mails. As it was necessary, in order that this last act might be effective, that the post offices of the country should be first furnished with metric balances, it was left discretionary with the postmaster-general to supply such balances at his convenience — a discretion which that officer has not yet seen fit to exercise.

At the August meeting of the Academy following this legislation, resolutions were adopted expressing the gratification of the Academy at this action of congress, which was declared to be "honorable to our country, as identifying it with the scientific progress of the age." The Academy at the same time earnestly recommended to state officers having charge of the subject of public education, "to require the employment of the metric system in works on arithmetic and other branches of science taught in the public schools, and to take such other measures as may insure the

introduction of the system by educating the people to appreciate its advantages."

These views were still more strongly enforced in resolutions adopted at the January meeting of the Academy in 1867, next succeeding; and in view of the unanticipated delay of the post-office department in introducing metric weights into the mail service, an additional resolution was adopted in the following words: —

"*Resolved*, That the Academy consider it highly desirable that the discretionary power granted by congress to the postmaster-general to use metric weights in the post-office department, be exercised at the earliest day."

A year later, in January 1868, the delay still continuing, a committee was appointed to wait on the postmaster-general, to present to him this resolution, and to endeavor to obtain from him some assurance that the object desired would be speedily accomplished. The committee reported on the following day that they had been courteously received, and that the postmaster-general had in their presence given such directions to his chief clerk, as to satisfy them of his intention to give effect to the law without delay. No result however followed from this movement.

In August, 1867, the committee on weights and measures were "authorized and directed to communicate with individuals and corporations representing the various trades throughout the country, tendering advice and assistance in any efforts they may be disposed to make in regard to the introduction of metric weights and measures."

When, in 1875, an invitation from the government of France was received by that of the United States, to participate in a diplomatic conference, called for the purpose of framing a convention for the creation and maintenance of an international bureau of weights and measures, the question as to the expediency of accepting the invitation was referred by the president of the United States to this Academy. On the favorable report of the committee of the Academy on weights and measures, the president appointed a representative to attend the conference, and subsequently gave the executive assent to the treaty negotiated by that congress. Th

treaty was submitted to the senate in December, 1875, and referred to the committee on foreign relations, which for two entire sessions of congress, and for nearly six months of a third, failed to report it for action. At a meeting of the Academy held in April, 1878, an earnest petition was addressed by this body to both houses of congress, praying the senate to ratify the treaty, and the lower house to make provision to meet the pecuniary obligations which the ratification might impose upon the United States. This petition produced the desired effect, and the ratification prayed for took place a few weeks later.

The international bureau of weights and measures had, however, already, by the concurrence of the leading European powers, become an established institution. It had been provided, by the liberality of the government of France, with an admirable site for its operations, upon elevated ground overlooking the village of Sèvres, already occupied by a beautiful pavilion, once a place of royal and imperial retirement and recreation, well adapted to furnish for it a council chamber, a residence for the director, and convenient offices for the administration; and there had been constructed for its use an additional building, forty meters by sixteen in the dimensions of its plan, provided with all the desirable facilities for the comparison and verification of measures, and for investigating the laws of the dilatation and contraction of metals through a great range of temperatures.

The bureau has been organized by the appointment of a director, with a competent staff of assistants, and is under the general control of an international executive committee consisting of fourteen members, of whom no two are of the same country. In this committee, the United States are represented by Professor J. E. Hilgard, a member of this Academy. The executive committee in turn owe their appointment to a general congress of delegates from all the treaty powers, which assemble every six years.

This recapitulation of the past acts of the Academy in reference to questions of metrological interest, has been presented by way of introduction to the question whether, in the present state of public opinion on the subject of metrological reform in this country, some further action on the part of this body might not be proper, with a view not only to promote by its influence the very obvious tendency

in the present age to the unification of the systems of weight and measure of all nations, but also to preserve the consistency of its own record.

The metric system of weights and measures has now been adopted by all the nations of continental Europe, for exclusive use in business transactions, with the exception of Russia, and the partial exception of Denmark. In all but one or two of these, the laws making the use compulsory have already taken effect, and in those which remain, they will do so within the next few years.

Throughout all the American continent south of the territory of the United States, the same system, though not in universal use, is the only one legal, and is destined in the progress of time to supersede all others.

The same system has been adopted for the extensive territory of the British possessions in India by the governor-general in council, with the approval of the home government, to be progressively introduced with as much expedition as the convenience of commerce may allow.

The imperial government of Russia has manifested a disposition to adopt the same system for use in that empire; having instituted an inquiry, by a commission appointed in the latter part of 1876, as to the results of the legislation of western and central Europe on the subject, and having received from that commission a favorable report.

In Great Britain a strong public sentiment favors the abolition of the existing system of weights and measures in favor of the metric. Bills providing for such a change have been repeatedly introduced into parliament; and one of these, under a former ministry, failed of success by the narrow majority of only five votes.

The science of Great Britain is entirely on the side of the metric system, and has to a large extent adopted it in use; as is illustrated in the fact that in the accounts of the explorations of H. B. M. ship "Challenger," under Sir Wyville Thomson, published in the scientific journals, all quantities are stated in metric denominations, and even the distances sailed over by the ship are given in kilometers.

In our own country, the metric weights and measures have been

extensively adopted by the medical profession, having been recommended by the state medical societies of New York, Massachusetts and Rhode Island, by the National College of Pharmacy, and the American Pharmaceutical Association; and having been actually made obligatory in the Marine Hospital service, by order of the Supervising Surgeon-General, approved by the Secretary of the Treasury.

Some of the large manufacturing establishments of the country have introduced the same system into their workshops. The Waltham Watch Manufacturing Co. is an example of these.

Several of our states, as for instance Massachusetts, Connecticut and New Jersey, have required instruction in the metric system to be given in all their primary schools. The state last named has made an appropriation to provide for supplying the schools with apparatus for the visible illustration of the system.

Educational organizations, local and general, in various parts of the United States, have adopted resolutions recommending the speedy introduction of the system into general use. One of our colleges, — Amherst College, Massachusetts — employs the metric denominations only in the statements of quantity, in every part of her course of instruction.

Many of the scientific associations of the country, — as for instance the American Association for the Advancement of Science, — and organizations of the scientific professions, have declared themselves by resolution in favor of the adoption of the metric weights and measures, either in the service of the government or for general use, and have memoralized congress to this effect.

Societies have been organized expressly to promote this movement, such as the American Metrological Society, and the American Metric Bureau; the last named of which has been for several years engaged in a very active and very effective agitation of the subject, by the wide circulation of documents, and by scattering over the country the metric weights and measures themselves, which the society furnishes at nominal prices.

Petitions have been addressed to congress signed by great numbers of our fellow-citizens, invoking such legislation as may facilitate the introduction of the metric weights and measures into our country, by employing them in such branches of the public service

as may bring them to the attention of the people without materially interfering with the ordinary modes of transacting business between individuals, such as the post office, the custom house, and the mint.

One of these petitions, presented to the forty-third congress, embraced signatures of importing merchants and other business men of our principal entrepôt of commerce, representing hundreds of millions of dollars.

Other petitions, less numerously but still very numerously signed, have prayed for action looking to more expeditious results; as, for instance, the fixing of a day in the not very distant future, from and after which the metric system of weights and measures shall alone be legal in all business transactions in the United States.

The committee of weights and measures of the house of representatives of the forty-fifth congress, presented during the last session of that body a report embracing a large amount of information in regard to the progress made towards the unification of weights and measures throughout the world; together with a series of responses received from the heads of departments of the executive government, as to the objections which may exist to the introduction of metric denominations of weight and measure into the business of the government, and into transactions between individuals; and also as to the length of time which ought to be allowed to elapse in case of such introduction, before the use of the new system should be made obligatory.

In view of the evidence before them, the committee express themselves in their report strongly of the opinion, that the question of the substitution of the metric system in this country for that which at present prevails, is no longer a question of feasibility or expediency, but only a question of time; and while they do not for the present propose any measure of legislation so radical as that of fixing a positive date in the future at which the change shall be made, they recommend that the use of the system in the postal service, which has so long been discretionary with the postmaster-general without being introduced, shall be made obligatory, and that custom duties on imported merchandise shall hereafter be levied in accordance with metric denominations of quantity.

By an international convention entered into in 1874 between the leading powers of the civilized world, the metric weights were adopted for the international postal service among all the nations, metric and non-metric alike, belonging to the General Postal Union then established. Of this convention, the government of the United States is one of the signatory powers. On all our correspondence with Europe, the use of the metric weights in our post office is compulsory; so that at this time we have two systems of postal weight, and two postal tariffs, the one for our foreign and the other for our domestic letters. To extend the metric system to both would be a change in the direction of simplicity.

As for the use of the metric denominations in the custom house, it would be obviously promotive of convenience both to importers and to the officers of the customs, in so far as importations from metric countries are concerned, which constitute (including the dependencies of those countries) according to an exhibit appended to the response of the secretary of the treasury to the committee of the house, about one-half of the entire amount; while the other half is derived mainly from Great Britain and her dependencies. The British measures of length and weight are identical with our own; but her capacity measures differ; so that of the total value of the merchandise received in our ports from foreign countries, only about one-fifth or one-fourth is invoiced in denominations identical with those in use among us, while one-half is invoiced in metric denominations.

Without regard, therefore, to the probability or possibility that Great Britain may before many years discard her present system of weights and measures in favor of the metric, there can be no doubt that it would be sensibly to the advantage of American importers, and would also materially reduce the labor of computations in American custom houses, were it to be required by law that all customs-duties should be assessed according to metric denomination. But whether or not such a law should be made universally applicable, it would at least be desirable that the laws should establish equivalent rates, and permit or require the assessment of duties upon invoices expressed metrically to be made in metric denominations, while upon others they should continue to be levied as at present.

In regard to our coinage, very little is required to bring it into complete conformity with the metric system. The subsidiary silver coin is already metric by law. The gold coin may be made metric by a modification of weight affecting the value to less than one-third of one per cent. The silver dollar of 412½ grains contains of pure silver twenty-four grams with only three-fiftieths of a gram, or about seven-eighths of a grain of excess in weight, and with less than one quarter of one per cent. of excess in value. All the coins issued from the mints of the United States could therefore be adjusted to a metric standard, by means of changes so slight as to be nearly imperceptible. But whether this adjustment is affected or not, it is certainly desirable, as it would be easy, to express the actually existing weights of our coins in grams and milligrams, instead of in grains and fractions of grains as at present.

The report of the committee of the house above referred to was submitted too late in the session to allow the propositions presented in it to come up for consideration before the expiration of the forty-fifth congress. They will probably be revived during the first regular session of the forty-sixth.

It has seemed to this committee that an expression of opinion on the part of the Academy, in the meantime made, in regard to the matters involved in those propositions, would have influence with congress; and that such an expression would be especially proper, considering the past record of the Academy itself. They have accordingly prepared a preamble and resolutions re-affirming the positions heretofore taken by the Academy on the subject, which are appended to this report, and are recommended for adoption.

RESOLUTIONS.

Whereas, The metric system of weights and measures has been very generally adopted for exclusive use in the expression of quantity among civilized peoples; and

Whereas, The probability of the ultimate universal prevalence of this system is becoming daily more and more decided; and

Whereas, These considerations suggest the advisability of making preparation for the possible introduction of this system sooner or later into use in this country also; therefore,

Resolved, That, in the opinion of this Academy, it is desirable, with a view

to such preparation, that provision should be made by state legislation for giving instruction in the principles of the metric system in all the elementary schools of the country, and for making a knowledge of the system a requisite for admission into educational institutions of higher grade; also,

That laws should be enacted by congress requiring the use, in the domestic mail service, of a metric unit of postal weight identical with that already employed in the foreign; providing for the assessment of duties upon merchandise imported under metric invoices to be made in accordance with a tariff adapted to metric denominations of weight and measure; and expressing the weights of all coins issued from the mints of the United States in grams and milligrams, and no longer in grains and fractions of grains as at present.

Resolved, That copies of the foregoing resolutions, duly authenticated, be communicated to the president of the United States, to the president of the senate, the speaker of the house of representatives, the chairman of the committee of finance of the senate, the chairman of the committee of the house on weights, measures and coinage, and the governors of the several states and territories.

All which is respectfully submitted.

F. A. P. Barnard, *Chairman.*

Tables of Weights and Measures in use in the United States, with their Metric Equivalents.

The tables which follow were prepared by Prof. Hubert A. Newton, of Yale College, New Haven, in 1866, for the use especially of teachers and authors of arithmetics; but also to facilitate the employment of metric denominations of quantity in business affairs, as authorized by the act of congress of July of that year. They were first published as an appendix to the annual report of the Smithsonian Institution for 1865 (made in 1866), and were subsequently republished for wider circulation, in pamphlet form. The author has kindly consented to their reproduction here, and they are reprinted from electrotypes which the secretary of the institution above named has courteously allowed to be taken from the original plates.

As the tables are intended for practical purposes, extended decimals are avoided. The meter is taken at 39.37 inches; the kilogram at 2.2046 pounds avoirdupois; the litre at 61.02 cubic inches. The capacity of the bushel is assumed to be 2150.42 cubic inches; and that of the gallon, 231 cubic inches.

In employing the table, units are to be looked for in the horizontal head-line, and tens in the vertical left-hand column.

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TABLE I.—*For converting kilometres into miles.*

Kilometres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	.621	1.243	1.864	2.485	3.107	3.728	4.350	4.971	5.592
10	6.214	6.835	7.456	8.078	8.699	9.321	9.942	10.563	11.185	11.806
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.777	17.398	18.020
30	18.641	19.262	19.884	20.505	21.127	21.748	22.369	22.991	23.612	24.233
40	24.855	25.476	26.098	26.719	27.340	27.962	28.583	29.204	29.826	30.447
50	31.068	31.690	32.311	32.933	33.554	34.175	34.797	35.418	36.039	36.661
60	37.282	37.904	38.525	39.146	39.768	40.389	41.010	41.632	42.253	42.875
70	43.496	44.117	44.739	45.360	45.981	46.603	47.224	47.845	48.467	49.088
80	49.710	50.331	50.952	51.574	52.195	52.816	53.438	54.059	54.681	55.302
90	55.923	56.545	57.166	57.787	58.409	59.030	59.652	60.273	60.894	61.516

TABLE II.—*For converting miles (of 5,280 feet) into metres.*

(To convert miles into kilometres use this table and divide the result by 1,000.)

Miles.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	00	1609	3219	4828	6437	8047	9656	11265	12875	14484
10	16093	17703	19312	20922	22531	24140	25750	27359	28968	30578
20	32187	33796	35406	37015	38624	40234	41843	43452	45062	46671
30	48280	49890	51499	53108	54718	56327	57936	59546	61155	62765
40	64374	65983	67593	69202	70811	72421	74030	75639	77249	78858
50	80467	82077	83686	85295	86905	88514	90123	91733	93342	94951
60	96561	98170	99780	101389	102998	104608	106217	107826	109436	111045
70	112654	114264	115873	117482	119092	120701	122310	123920	125529	127138
80	128748	130357	131966	133576	135185	136795	138404	140013	141623	143232
90	144841	146451	148060	149669	151279	152888	154497	156107	157716	159325

TABLE III.—*For converting kilometres into feet.*

(To convert metres into feet use this table and divide the result by 1,000.)

Kilometres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	3281	6562	9842	13123	16404	19685	22966	26247	29527
10	32808	36089	39370	42651	45932	49212	52493	55774	59055	62336
20	65617	68897	72178	75459	78740	82021	85302	88582	91863	95144
30	98425	101706	104987	108267	111548	114829	118110	121391	124672	127952
40	131233	134514	137795	141076	144357	147637	150918	154199	157480	160761
50	164042	167322	170603	173884	177165	180446	183727	187007	190288	193569
60	196850	200131	203412	206692	209973	213254	216535	219816	223097	226377
70	229658	232939	236220	239501	242782	246062	249343	252624	255905	259186
80	262467	265747	269028	272309	275590	278871	282152	285432	288713	291994
90	295275	298556	301837	305117	308398	311679	314960	318241	321522	324802

TABLE IV.—*For converting feet into millimetres.*

(Divide the result by 1,000 to obtain metres.)

Feet.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	305	610	914	1219	1524	1829	2134	2438	2743
10	3048	3353	3658	3962	4267	4572	4877	5182	5486	5791
20	6096	6401	6706	7010	7315	7620	7925	8230	8534	8839
30	9144	9449	9754	10058	10363	10668	10973	11278	11582	11887
40	12192	12497	12802	13106	13411	13716	14021	14326	14630	14935
50	15240	15545	15850	16154	16459	16764	17069	17374	17678	17983
60	18288	18593	18898	19202	19507	19812	20117	20422	20726	21031
70	21336	21641	21946	22250	22555	22860	23165	23470	23774	24079
80	24384	24689	24994	25298	25603	25908	26213	26518	26822	27127
90	27432	27737	28042	28346	28651	28956	29261	29566	29870	30175

TABLE V.—*For converting metres into feet and inches.*

Metres.	0.	0.1.	0.2.	0.3.	0.4.	0.5.	0.6.	0.7.	0.8.	0.9.
	Ft. In.	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*	*Ft. In.*
0	0 0	0 3.9	0 7.9	0 11.8	1 3.7	1 7.7	1 11.6	2 3.6	2 7.5	2 11.4
1	3 3.4	3 7.3	3 11.2	4 3.2	4 7.1	4 11.1	5 3.0	5 6.9	5 10.9	6 2.8
2	6 6.7	6 10.7	7 2.6	7 6.6	7 10.5	8 2.4	8 6.4	8 10.3	9 2.2	9 6.2
3	9 9.1	10 2.0	10 6.0	10 9.9	11 1.9	11 5.8	11 9.7	12 1.7	12 5.6	12 9.5
4	13 1.5	13 5.4	13 9.4	14 1.3	14 5.2	14 9.2	15 1.1	15 5.0	15 9.0	16 0.9
5	16 4.8	16 8.8	17 0.7	17 4.7	17 8.6	18 0.5	18 4.5	18 9.4	19 0.3	19 4.3
6	19 8.2	20 0.2	20 4.1	20 8.0	21 0.0	21 3.9	21 7.8	21 11.8	22 3.7	22 7.7
7	22 11.6	23 3.5	23 7.5	23 11.4	24 3.3	24 7.3	24 11.2	25 3.1	25 7.1	25 11.0
8	26 3.0	26 6.9	26 10.8	27 2.8	27 6.7	27 10.6	28 2.6	28 6.5	28 10.5	29 2.4
9	29 6.3	29 10.3	30 2.2	30 6.1	30 10.1	31 2.0	31 6.0	31 9.9	32 1.8	32 5.8

TABLE VI.—*For converting inches and fractions into millimetres.*

Inches.	0	$\frac{1}{12}$	$\frac{1}{8}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{3}{8}$	$\frac{5}{12}$	$\frac{1}{2}$	$\frac{7}{12}$	$\frac{5}{8}$	$\frac{2}{3}$	$\frac{3}{4}$	$\frac{5}{6}$	$\frac{7}{8}$	$\frac{11}{12}$
0	0	2.1	3.2	4.2	6.4	8.5	9.5	10.6	12.7	14.8	15.9	16.9	19.1	21.2	22.2	23.3
1	25.4	27.5	28.6	29.6	31.8	33.9	34.9	36.0	38.1	40.2	41.3	42.3	44.5	46.6	47.6	48.7
2	50.8	52.9	54.0	55.0	57.3	59.3	60.3	61.4	63.5	65.6	66.7	67.7	69.9	72.0	73.0	74.1
3	76.2	78.3	79.4	80.4	82.6	84.7	85.7	86.8	88.9	91.0	92.1	93.1	95.3	97.4	98.4	99.5
4	101.6	103.7	104.8	105.8	108.0	110.1	111.1	112.2	114.3	116.4	117.5	118.5	120.7	122.8	123.8	124.9
5	127.0	129.1	130.2	131.2	133.4	135.5	136.5	137.6	139.7	141.8	142.9	143.9	146.1	148.2	149.2	150.3
6	152.4	154.5	155.6	156.6	158.8	160.9	161.9	163.0	165.1	167.2	168.3	169.3	171.5	173.6	174.6	175.7
7	177.8	179.9	181.0	182.0	184.2	186.3	187.3	188.4	190.5	192.6	193.7	194.7	196.9	199.0	200.0	201.1
8	203.2	205.3	206.4	207.4	209.6	211.7	212.7	213.8	215.9	218.0	219.1	220.1	222.3	224.4	225.4	226.5
9	228.6	230.7	231.8	232.8	235.0	237.1	238.1	239.2	241.3	243.4	244.5	245.5	247.7	249.8	250.8	251.9
10	254.0	256.1	257.2	258.2	260.4	262.5	263.5	264.6	266.7	268.8	269.9	270.9	273.1	275.2	276.2	277.3
11	279.4	281.5	282.6	283.6	285.8	287.9	288.9	290.0	292.1	294.2	295.3	296.3	298.5	300.6	301.6	302.7

TABLE VII.—*For converting metres into inches.*

Metres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	39.4	78.7	118.1	157.5	196.8	236.2	275.6	315.0	354.3
10	393.7	433.1	472.4	511.8	551.2	590.5	629.9	669.3	708.7	748.0
20	787.4	826.8	866.1	905.5	944.9	984.2	1023.6	1063.0	1102.4	1141.7
30	1181.1	1220.5	1259.8	1299.2	1338.6	1377.9	1417.3	1456.7	1496.1	1535.4
40	1574.8	1614.2	1653.5	1692.9	1732.3	1771.6	1811.0	1850.4	1889.8	1929.1
50	1968.5	2007.9	2047.2	2086.6	2126.0	2165.3	2204.7	2244.1	2283.5	2322.8
60	2362.2	2401.6	2440.9	2480.3	2519.7	2559.0	2598.4	2637.8	2677.2	2716.5
70	2755.9	2795.3	2834.6	2874.0	2913.4	2952.7	2992.1	3031.5	3070.9	3110.2
80	3149.6	3189.0	3228.3	3267.7	3307.1	3346.4	3385.8	3425.2	3464.6	3503.9
90	3543.3	3582.7	3622.0	3661.4	3700.8	3740.1	3779.5	3818.9	3858.3	3897.6

TABLE VIII.—*For converting inches into millimetres.*

Inches.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	25.4	50.8	76.2	101.6	127.0	152.4	177.8	203.2	228.6
10	254.0	279.4	304.8	330.2	355.6	381.0	406.4	431.8	457.2	482.6
20	508.0	533.4	558.8	584.2	609.6	635.0	660.4	685.8	711.2	736.6
30	762.0	787.4	812.8	838.2	863.6	889.0	914.4	939.8	965.2	990.6
40	1016.0	1041.4	1066.8	1092.2	1117.6	1143.0	1168.4	1193.8	1219.2	1244.6
50	1270.0	1295.4	1320.8	1346.2	1371.6	1397.0	1422.4	1447.8	1473.2	1498.6
60	1524.0	1549.4	1574.8	1600.2	1625.6	1651.0	1676.4	1701.8	1727.2	1752.6
70	1778.0	1803.4	1828.8	1854.2	1879.6	1905.0	1930.4	1955.8	1981.2	2006.6
80	2032.0	2057.4	2082.8	2108.2	2133.6	2159.0	2184.4	2209.8	2235.2	2260.6
90	2286.0	2311.4	2336.8	2362.2	2387.6	2413.0	2438.4	2463.8	2489.2	2514.6

TABLE IX.—*For converting hectares into acres.*

Hectares.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	2.47	4.94	7.41	9.88	12.36	14.83	17.30	19.77	22.24
10	24.71	27.18	29.65	32.12	34.59	37.07	39.54	42.01	44.48	46.95
20	49.42	51.89	54.36	56.83	59.31	61.78	64.25	66.72	69.19	71.66
30	74.13	76.60	79.07	81.54	84.02	86.49	88.96	91.43	93.90	96.37
40	98.84	101.31	103.78	106.25	108.73	111.20	113.67	116.14	118.61	121.08
50	123.55	126.02	128.49	130.97	133.44	135.91	138.38	140.85	143.32	145.79
60	148.26	150.73	153.20	155.68	158.15	160.62	163.09	165.56	168.03	170.50
70	172.97	175.44	177.92	180.39	182.86	185.33	187.80	190.27	192.74	195.21
80	197.68	200.15	202.63	205.10	207.57	210.04	212.51	214.98	217.45	219.92
90	222.39	224.87	227.34	229.81	232.28	234.75	237.22	239.69	242.16	244.63

TABLE X.—*For converting acres into hectares.*

Acres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	.405	.809	1.214	1.619	2.023	2.428	2.833	3.237	3.642
10	4.047	4.452	4.856	5.261	5.666	6.070	6.475	6.880	7.284	7.689
20	8.094	8.498	8.903	9.308	9.712	10.117	10.522	10.927	11.331	11.736
30	12.141	12.545	12.950	13.355	13.759	14.164	14.569	14.973	15.378	15.783
40	16.187	16.592	16.997	17.402	17.806	18.211	18.616	19.020	19.425	19.830
50	20.234	20.639	21.044	21.448	21.853	22.258	22.662	23.067	23.472	23.877
60	24.281	24.686	25.091	25.495	25.900	26.305	26.709	27.114	27.519	27.923
70	28.328	28.733	29.137	29.542	29.947	30.352	30.756	31.161	31.566	31.970
80	32.375	32.780	33.184	33.589	33.994	34.398	34.803	35.208	35.612	36.017
90	36.422	36.827	37.231	37.636	38.041	38.445	38.850	39.255	39.659	40.064

TABLE XI.—*For converting square kilometres into square miles.*

Square kilometres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	0.386	0.772	1.158	1.544	1.931	2.317	2.703	3.089	3.475
10	3.861	4.247	4.633	5.019	5.405	5.792	6.178	6.564	6.950	7.336
20	7.722	8.108	8.494	8.880	9.266	9.653	10.039	10.425	10.811	11.197
30	11.583	11.969	12.355	12.741	13.127	13.514	13.900	14.286	14.672	15.058
40	15.444	15.830	16.216	16.602	16.988	17.375	17.761	18.147	18.533	18.919
50	19.305	19.691	20.077	20.463	20.849	21.236	21.622	22.008	22.394	22.780
60	23.166	23.552	23.938	24.324	24.710	25.097	25.483	25.869	26.255	26.641
70	27.027	27.413	27.799	28.185	28.571	28.958	29.344	29.730	30.116	30.502
80	30.888	31.274	31.660	32.046	32.432	32.819	33.205	33.591	33.977	34.363
90	34.749	35.135	35.521	35.907	36.293	36.680	37.066	37.452	37.838	38.224

TABLE XII.—*For converting square miles into hectares.*

(To convert square miles into square kilometres use this table and divide the result by 100.)

Square miles.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	259	518	777	1036	1295	1554	1813	2072	2331
10	2590	2849	3108	3367	3626	3885	4144	4403	4662	4921
20	5180	5439	5698	5957	6216	6475	6734	6993	7252	7511
30	7770	8029	8288	8547	8806	9065	9324	9583	9842	10101
40	10360	10619	10878	11137	11396	11655	11914	12173	12432	12691
50	12950	13209	13468	13727	13986	14245	14504	14763	15022	15281
60	15540	15799	16058	16317	16576	16835	17094	17353	17612	17871
70	18130	18389	18648	18907	19166	19425	19684	19943	20202	20461
80	20720	20979	21238	21497	21756	22015	22274	22533	22792	23051
90	23310	23569	23828	24087	24346	24605	24864	25123	25382	25641

TABLE XIII.—*For converting centares or square metres into square yards.*

Centares.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	1.196	2.392	3.588	4.784	5.980	7.176	8.372	9.568	10.764
10	11.960	13.156	14.352	15.548	16.744	17.940	19.136	20.332	21.528	22.724
20	23.920	25.116	26.312	27.508	28.704	29.900	31.096	32.292	33.488	34.684
30	35.880	37.076	38.272	39.468	40.663	41.859	43.055	44.251	45.447	46.643
40	47.839	49.035	50.231	51.427	52.623	53.819	55.015	56.211	57.407	58.603
50	59.799	60.995	62.191	63.387	64.583	65.779	66.975	68.171	69.367	70.563
60	71.759	72.955	74.151	75.347	76.543	77.739	78.935	80.131	81.327	82.523
70	83.719	84.915	86.111	87.307	88.503	89.699	90.895	92.091	93.287	94.483
80	95.679	96.875	98.071	99.267	100.463	101.659	102.855	104.051	105.247	106.443
90	107.639	108.835	110.031	111.227	112.423	113.619	114.815	116.011	117.207	118.403

TABLE XIV.—*For converting square yards into centares or square metres.*

Square yards.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	0.836	1.672	2.508	3.345	4.181	5.017	5.853	6.689	7.525
10	8.361	9.197	10.034	10.870	11.706	12.542	13.378	14.214	15.050	15.886
20	16.723	17.559	18.395	19.231	20.067	20.903	21.739	22.576	23.412	24.248
30	25.084	25.920	26.756	27.592	28.428	29.265	30.101	30.937	31.773	32.609
40	33.445	34.281	35.117	35.954	36.790	37.626	38.462	39.298	40.134	40.970
50	41.807	42.643	43.479	44.315	45.151	45.987	46.823	47.659	48.496	49.332
60	50.168	51.004	51.840	52.676	53.512	54.348	55.185	56.021	56.857	57.693
70	58.529	59.365	60.201	61.038	61.874	62.710	63.546	64.382	65.218	66.054
80	66.890	67.727	68.563	69.399	70.235	71.071	71.907	72.743	73.580	74.416
90	75.252	76.088	76.924	77.760	78.596	79.432	80.269	81.105	81.941	82.777

TABLE XV.—*For converting square metres or centares into square feet.*

Square metres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	10.76	21.53	32.29	43.06	53.82	64.58	75.35	86.11	96.87
10	107.64	118.40	129.17	139.93	150.69	161.46	172.22	182.99	193.75	204.51
20	215.28	226.04	236.81	247.57	258.33	269.10	279.86	290.62	301.39	312.15
30	322.92	333.68	344.44	355.21	365.97	376.74	387.50	398.26	409.03	419.79
40	430.55	441.32	452.08	462.85	473.61	484.37	495.14	505.90	516.67	527.43
50	538.19	548.96	559.72	570.48	581.25	592.01	602.78	613.54	624.30	635.07
60	645.83	656.60	667.36	678.12	688.89	699.65	710.42	721.18	731.94	742.71
70	753.47	764.23	775.00	785.76	796.53	807.29	818.05	828.82	839.58	850.35
80	861.11	871.87	882.64	893.40	904.16	914.93	925.69	936.46	947.22	957.98
90	968.75	979.51	990.28	1001.04	1011.80	1022.57	1033.33	1044.10	1054.86	1065.62

TABLE XVI.—*For converting square feet into square decimetres.*

(Divide the result by 100 to obtain square metres.)

Square feet.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	9.29	18.58	27.87	37.16	46.45	55.74	65.03	74.32	83.61
10	92.90	102.19	111.48	120.77	130.06	139.36	148.65	157.94	167.23	176.52
20	185.81	195.10	204.39	213.68	222.97	232.26	241.55	250.84	260.13	269.42
30	278.71	288.00	297.29	306.58	315.87	325.16	334.45	343.74	353.03	362.32
40	371.61	380.90	390.19	399.48	408.78	418.07	427.36	436.65	445.94	455.23
50	464.52	473.81	483.10	492.39	501.68	510.97	520.26	529.55	538.84	548.13
60	557.42	566.71	576.00	585.29	594.58	603.87	613.16	622.45	631.74	641.03
70	650.32	659.61	668.90	678.19	687.49	696.78	706.07	715.36	724.65	733.94
80	743.23	752.52	761.81	771.10	780.39	789.68	798.97	808.26	817.55	826.84
90	836.13	845.42	854.71	864.00	873.29	882.58	891.87	901.16	910.45	919.74

TABLE XVII.—*For converting square metres or centares into square inches.*

Square metres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	1550	3100	4650	6200	7750	9300	10850	12400	13950
10	15500	17050	18600	20150	21700	23250	24800	26350	27900	29450
20	31000	32550	34100	35650	37200	38750	40300	41850	43400	44950
30	46500	48050	49600	51150	52700	54250	55800	57350	58900	60450
40	62000	63550	65100	66650	68200	69750	71300	72850	74400	75950
50	77500	79050	80600	82150	83700	85250	86800	88350	89900	91450
60	93000	94550	96100	97650	99200	100750	102300	103850	105400	106950
70	108500	110050	111600	113150	114700	116250	117800	119350	120900	122450
80	124000	125550	127100	128650	130200	131750	133300	134850	136400	137950
90	139500	141050	142600	144150	145700	147250	148800	150350	151900	153450

TABLE XVIII.—*For converting square inches into square centimetres.*

(Divide the number of square centimetres by 10,000 to obtain square metres.)

Square inches.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	6.45	12.90	19.35	25.81	32.26	38.71	45.16	51.61	58.06
10	64.52	70.97	77.42	83.87	90.32	96.77	103.23	109.68	116.13	122.58
20	129.03	135.48	141.94	148.39	154.84	161.29	167.74	174.19	180.65	187.10
30	193.55	200.00	206.45	212.90	219.36	225.81	232.26	238.71	245.16	251.61
40	258.07	264.52	270.97	277.42	283.87	290.32	296.77	303.23	309.68	316.13
50	322.58	329.03	335.48	341.94	348.39	354.84	361.29	367.74	374.19	380.65
60	387.10	393.55	400.00	406.45	412.90	419.36	425.81	432.26	438.71	445.16
70	451.61	458.07	464.52	470.97	477.42	483.87	490.32	496.78	503.23	509.68
80	516.13	522.58	529.03	535.48	541.94	548.39	554.84	561.29	567.74	574.19
90	580.65	587.10	593.55	600.00	606.45	612.90	619.36	625.81	632.26	638.71

TABLE XIX.—*For converting cubic metres or steres into cubic yards.*

Cubic metres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	1.308	2.616	3.924	5.232	6.540	7.848	9.156	10.464	11.7[illegible]
10	13.079	14.387	15.695	17.003	18.311	19.619	20.927	22.235	23.543	24.8[illegible]
20	26.159	27.467	28.775	30.083	31.391	32.699	34.007	35.314	36.622	37.9[illegible]
30	39.238	40.546	41.854	43.162	44.470	45.778	47.086	48.394	49.702	51.010
40	52.318	53.626	54.934	56.242	57.549	58.857	60.165	61.473	62.781	64.089
50	65.397	66.705	68.013	69.321	70.629	71.937	73.245	74.553	75.861	77.169
60	78.477	79.785	81.092	82.400	83.708	85.016	86.324	87.632	88.940	90.248
70	91.556	92.864	94.172	95.480	96.788	98.096	99.404	100.712	102.020	103.327
80	104.635	105.943	107.251	108.559	109.867	111.175	112.483	113.791	115.099	116.407
90	117.715	118.023	120.331	121.639	122.947	124.255	125.563	126.870	128.178	129.486

TABLE XX.—*For converting cubic yards into litres.*

(To convert cubic yards into steres or cubic metres use this table and divide the result by 1,000.)

Cubic yards.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	765	1529	2294	3058	3823	4587	5352	6116	6881
10	7646	8410	9175	9939	10704	11468	12233	12998	13762	14527
20	15291	16056	16820	17585	18349	19114	19879	20643	21408	22172
30	22937	23701	24466	25230	25995	26760	27524	28289	29053	29818
40	30582	31347	32111	32876	33641	34405	35170	35934	36699	37463
50	38228	38993	39757	40522	41286	42051	42815	43580	44344	45109
60	45874	46638	47403	48167	48932	49696	50461	51225	51990	52755
70	53519	54284	55048	55813	56577	57342	58107	58871	59636	60400
80	61165	61929	62694	63458	64223	64988	65752	66517	67281	68046
90	68810	69575	70339	71104	71869	72633	73398	74162	74927	75691

TABLE XXI.—*For converting cubic feet into litres or cubic decimetres.*

(Divide the number of litres by 1,000 for cubic metres.)

Cubic feet.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	28.3	56.6	85.0	113.3	141.6	169.9	198.2	226.5	254.9
10	283.2	311.5	339.8	368.1	396.4	424.8	453.1	481.4	509.7	538.0
20	566.3	594.7	623.0	651.3	679.6	707.9	736.2	764.6	792.9	821.2
30	849.5	877.8	906.1	934.5	962.8	991.1	1019.4	1047.7	1076.0	1104.4
40	1132.7	1161.0	1189.3	1217.6	1245.9	1274.3	1302.6	1330.9	1259.2	1387.5
50	1415.9	1444.2	1472.5	1500.8	1529.1	1557.4	1585.8	1614.1	1642.4	1670.7
60	1699.0	1727.3	1755.7	1784.0	1812.3	1840.6	1868.9	1897.2	1925.6	1953.9
70	1982.2	2010.5	2038.8	2067.1	2095.5	2123.8	2152.1	2180.4	2208.7	2237.0
80	2265.4	2293.7	2322.0	2350.3	2378.6	2406.9	2435.3	2463.6	2491.9	2520.2
90	2548.5	2576.8	2605.2	2633.5	2661.8	2690.1	2718.4	2746.7	2775.1	2803.4

TABLE XXII.—*For converting cubic metres into cubic feet.*

(To convert litres into cubic feet use this table and divide by 1,000.)

Cubic metres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	35.3	70.6	105.9	141.3	176.6	211.9	247.2	282.5	317.8
10	353.1	388.5	423.8	459.1	494.4	529.7	565.0	600.3	635.7	671.0
20	706.3	741.6	776.9	812.2	847.5	882.9	918.2	953.5	988.8	1024.1
30	1059.4	1094.7	1130.1	1165.4	1200.7	1236.0	1271.3	1306.6	1341.9	1377.3
40	1412.6	1447.9	1483.2	1518.5	1553.8	1589.2	1624.5	1659.8	1695.1	1730.4
50	1765.7	1801.0	1836.4	1871.7	1907.0	1942.3	1977.6	2012.9	2048.2	2083.6
60	2118.9	2154.2	2189.5	2224.8	2260.1	2295.4	2330.8	2366.1	2401.4	2436.7
70	2472.0	2507.3	2542.6	2578.0	2613.3	2648.6	2683.9	2719.2	2754.5	2789.8
80	2825.2	2860.5	2895.8	2931.1	2966.4	3001.7	3037.0	3072.4	3107.7	3143.0
90	3178.3	3213.6	3248.9	3284.2	3319.6	3354.9	3390.2	3425.5	3460.8	3496.1

TABLE XXIII.—*For converting litres into cubic inches.*

Litres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	61.0	122.0	183.1	244.1	305.1	366.1	427.2	488.2	549.2
10	610.2	671.3	732.3	793.3	854.3	915.4	976.4	1037.4	1098.4	1159.4
20	1220.5	1281.5	1342.5	1403.5	1464.6	1525.6	1586.6	1647.6	1708.7	1769.7
30	1830.7	1891.7	1952.8	2013.8	2074.8	2135.8	2196.8	2257.9	2318.9	2379.9
40	2440.9	2502.0	2563.0	2624.0	2685.0	2746.1	2807.1	2868.1	2929.1	2990.1
50	3051.2	3112.2	3173.2	3234.2	3295.3	3356.3	3417.3	3478.3	3539.4	3600.4
60	3661.4	3722.4	3783.5	3844.5	3905.5	3966.5	4027.5	4088.6	4149.6	4210.6
70	4271.6	4332.7	4393.7	4454.7	4515.7	4576.8	4637.8	4698.8	4759.8	4820.8
80	4881.9	4942.9	5003.9	5064.9	5126.0	5187.0	5248.0	5309.0	5370.1	5431.1
90	5492.1	5553.1	5614.2	5675.2	5736.2	5797.2	5858.2	5919.3	5980.3	6041.3

TABLE XXIV.—*For converting cubic inches into cubic centimetres.*

(To convert cubic inches into litres use this table and divide the result by 1,000.)

Cubic inches.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	16.4	32.8	49.2	65.5	81.9	98.3	114.7	131.1	147.5
10	163.9	180.3	196.6	213.0	229.4	245.8	262.2	278.6	295.0	311.4
20	327.7	344.1	360.5	376.9	393.3	409.7	426.1	442.5	458.8	475.2
30	491.6	508.0	524.4	540.8	557.2	573.6	589.9	606.3	622.7	639.1
40	655.5	671.9	688.3	704.6	721.0	737.4	753.8	770.2	786.6	803.0
50	819.4	835.7	852.1	868.5	884.9	901.3	917.7	934.1	950.5	966.8
60	983.2	999.6	1016.0	1032.4	1048.8	1065.2	1081.6	1097.9	1114.3	1130.7
70	1147.1	1163.5	1179.9	1196.3	1212.6	1229.0	1245.4	1261.8	1278.2	1294.6
80	1311.0	1327.4	1343.7	1360.1	1376.5	1392.9	1409.3	1425.7	1442.1	1458.5
90	1474.8	1491.2	1507.6	1524.0	1545.4	1556.8	1573.2	1589.6	1605.9	1622.3

TABLE XXV.—*For converting hectolitres into bushels.*

(To convert cubic metres to bushels use this table and multiply the result by 10.)

Hectolitres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	2.84	5.68	8.51	11.35	14.19	17.03	19.86	22.70	25.54
10	28.38	31.22	34.05	36.89	39.73	42.57	45.40	48.24	51.08	53.92
20	56.75	59.59	62.43	65.27	68.11	70.94	73.78	76.62	79.46	82.29
30	85.13	87.97	90.81	93.65	96.48	99.32	102.16	105.00	107.83	110.67
40	113.51	116.35	119.19	122.02	124.86	127.70	130.54	133.37	136.21	139.05
50	141.89	144.72	147.56	150.40	153.24	156.08	158.91	161.75	164.59	167.43
60	170.26	173.10	175.94	178.78	181.62	184.45	187.29	190.13	192.97	195.80
70	198.64	201.48	204.32	207.16	209.99	212.83	215.67	218.51	221.34	224.18
80	227.02	229.86	232.69	235.53	238.37	241.21	244.05	246.88	249.72	252.56
90	255.40	258.23	261.07	263.91	266.75	269.59	272.42	275.26	278.10	280.94

TABLE XXVI.—*For converting bushels into litres.*

Bushels.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	35.2	70.5	105.7	141.0	176.2	211.4	246.7	281.9	317.2
10	352.4	387.6	422.9	458.1	493.3	528.6	563.8	599.1	634.3	669.5
20	704.8	740.0	775.3	810.5	845.7	881.0	916.2	951.5	986.7	1021.9
30	1057.2	1092.4	1127.7	1162.9	1198.1	1233.4	1268.6	1303.9	1339.1	1374.3
40	1409.6	1444.8	1480.0	1515.3	1550.5	1585.8	1621.0	1656.2	1691.5	1726.7
50	1762.0	1797.2	1832.4	1867.7	1902.9	1938.2	1973.4	2008.6	2043.9	2079.1
60	2114.4	2149.6	2184.8	2220.1	2255.3	2290.6	2325.8	2361.0	2396.3	2431.5
70	2466.7	2502.0	2537.2	2572.5	2607.7	2642.9	2678.2	2713.4	2748.7	2783.9
80	2819.1	2854.4	2889.6	2924.9	2960.1	2995.3	3030.6	3065.8	3101.1	3136.3
90	3171.5	3206.8	3242.0	3277.3	3312.5	3347.7	3383.0	3418.2	3453.4	3488.7

TABLE XXVII.—*For converting hectolitres into wine gallons.*

Hectolitres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	26.42	52.83	79.25	105.67	132.09	158.50	184.92	211.34	237.75
10	264.17	290.59	317.00	343.42	369.84	396.26	422.67	449.09	475.51	501.92
20	528.34	554.76	581.18	607.59	634.01	660.43	686.84	713.26	739.68	766.09
30	792.51	818.93	845.35	871.76	898.18	924.60	951.01	977.43	1003.85	1030.26
40	1056.68	1083.10	1109.52	1135.93	1162.35	1188.77	1215.18	1241.60	1268.02	1294.44
50	1320.85	1347.27	1373.69	1400.10	1426.52	1452.94	1479.35	1505.77	1532.19	1558.61
60	1585.02	1611.44	1637.86	1664.27	1690.69	1717.11	1743.53	1769.94	1796.36	1822.78
70	1849.19	1875.61	1902.03	1928.44	1954.86	1981.28	2007.70	2034.11	2060.53	2086.95
80	2113.36	2139.78	2166.20	2192.61	2219.03	2245.45	2271.87	2298.28	2324.70	2351.12
90	2377.53	2403.95	2430.37	2456.79	2483.20	2509.62	2536.04	2562.45	2588.87	2615.29

TABLE XXVIII.—*For converting wine gallons into litres.*

Wine gallons.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	3.79	7.57	11.36	15.14	18.93	22.71	26.50	30.28	34.07
10	37.85	41.64	45.43	49.21	53.00	56.78	60.57	64.35	68.14	71.92
20	75.71	79.49	83.28	87.06	90.85	94.64	98.42	102.21	105.99	109.78
30	113.56	117.35	121.13	124.92	128.70	132.49	136.28	140.06	143.85	147.63
40	151.42	155.20	158.99	162.77	166.56	170.34	174.13	177.92	181.70	185.49
50	189.27	193.06	196.84	200.63	204.41	208.20	211.98	215.77	219.56	223.34
60	227.13	230.91	234.70	238.48	242.27	246.05	249.84	253.62	257.41	261.19
70	264.98	268.77	272.55	276.34	280.12	283.91	287.69	291.48	295.26	299.05
80	302.83	306.62	310.41	314.19	317.98	321.76	325.55	329.33	333.12	336.90
90	340.69	344.47	348.26	352.05	355.83	359.62	363.40	367.19	370.97	374.76

TABLE XXIX.—*For converting wine quarts into millilitres.*

(To convert quarts into litres use this table and divide the result by 1,000.)

Wine quarts.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	946	1893	2839	3785	4732	5678	6625	7571	8517
10	9464	10410	11356	12303	13249	14195	15142	16088	17034	17981
20	18927	19874	20820	21766	22713	23659	24605	25552	26498	27444
30	28391	29337	30283	31230	32176	33123	34069	35015	35962	36908
40	37854	38801	39747	40693	41640	42586	43532	44479	45425	46372
50	47318	48264	49211	50157	51103	52050	52996	53942	54889	55835
60	56782	57728	58674	59621	60567	61513	62460	63406	64352	65299
70	66245	67191	68138	69084	70031	70977	71923	72870	73816	74762
80	75709	76655	77601	78548	79494	80440	81387	82333	83280	84226
90	85172	86119	87065	88011	88958	89904	90850	91797	92743	93690

TABLE XXX.—*For converting hectolitres into wine quarts.*

(To convert litres into quarts use this table and divide the result by 100.)

Hectolitres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	105.7	211.3	317.0	422.7	528.3	634.0	739.7	845.3	951.0
10	1056.7	1162.3	1268.0	1373.7	1479.4	1585.0	1690.7	1796.4	1902.0	2007.7
20	2113.4	2219.0	2324.7	2430.4	2536.0	2641.7	2747.4	2853.0	2958.7	3064.4
30	3170.0	3275.7	3381.4	3487.1	3592.7	3698.4	3804.1	3909.7	4015.4	4121.1
40	4226.7	4332.4	4438.1	4543.7	4649.4	4755.1	4860.7	4966.4	5072.1	5177.7
50	5283.4	5389.1	5494.7	5600.4	5706.1	5811.8	5917.4	6023.1	6128.8	6234.4
60	6340.1	6445.8	6551.4	6657.1	6762.8	6868.4	6974.1	7079.8	7185.4	7291.1
70	7396.8	7502.4	7608.1	7713.8	7819.4	7925.1	8030.8	8136.5	8242.1	8347.8
80	8453.5	8559.1	8664.8	8770.5	8876.1	8981.8	9087.5	9193.1	9298.8	9404.5
90	9510.1	9615.8	9721.5	9827.1	9932.8	10038.5	10144.1	10249.8	10355.5	10461.2

TABLE XXXI.—*For converting litres into fluid ounces.*

Litres.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	33.8	67.6	101.4	135.3	169.1	202.9	236.7	270.5	304.3
10	338.1	372.0	405.8	439.6	473.4	507.2	541.0	574.8	608.6	642.5
20	676.3	710.1	743.9	777.7	811.5	845.3	879.2	913.0	946.8	980.6
30	1014.4	1048.2	1082.0	1115.9	1149.7	1183.5	1217.3	1251.1	1284.9	1318.7
40	1352.6	1386.4	1420.2	1454.0	1487.8	1521.6	1555.4	1589.2	1623.1	1656.9
50	1690.7	1724.5	1758.3	1792.1	1825.9	1859.8	1893.6	1927.4	1961.2	1995.0
60	2028.8	2062.6	2096.5	2130.3	2164.1	2197.9	2231.7	2265.5	2299.3	2333.2
70	2367.0	2400.8	2434.6	2468.4	2502.2	2536.0	2569.8	2603.7	2637.5	2671.3
80	2705.1	2738.9	2772.7	2806.5	2840.4	2874.2	2908.0	2941.8	2975.6	3009.4
90	3043.2	3077.1	3110.9	3144.7	3178.5	3212.3	3246.1	3279.9	3313.8	3347.6

TABLE XXXII.—*For converting fluid ounces into centilitres.*

Fluid ounces.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	2.96	5.91	8.87	11.83	14.79	17.74	20.70	23.66	26.62
10	29.57	32.53	35.49	38.45	41.40	44.36	47.32	50.28	53.23	56.19
20	59.15	62.10	65.06	68.02	70.98	73.93	76.89	79.85	82.81	85.76
30	88.72	91.68	94.64	97.59	100.55	103.51	106.47	109.42	112.38	115.34
40	118.29	121.25	124.21	127.17	130.12	133.08	136.04	139.00	141.95	144.91
50	147.87	150.83	153.78	156.74	159.70	162.66	165.61	168.57	171.53	174.48
60	177.44	180.40	183.36	186.31	189.27	192.23	195.19	198.14	201.10	204.06
70	207.02	209.97	212.93	215.89	218.85	221.80	224.76	227.72	230.67	233.63
80	236.59	239.55	242.50	245.46	248.42	251.38	254.33	257.29	260.25	263.21
90	266.16	269.12	272.08	275.04	277.99	280.95	283.91	286.86	289.82	292.78

TABLE XXXIII.—*For converting tonneaux or milliers into long tons, (of 2,240 pounds.)*

(To convert kilograms into long tons use this table and divide the result by 1,000.)

Tonneaux or milliers.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	0.984	1.968	2.953	3.937	4.921	5.905	6.889	7.874	8.858
10	9.842	10.826	11.810	12.795	13.779	14.763	15.747	16.731	17.716	18.700
20	19.684	20.668	21.652	22.637	23.621	24.605	25.589	26.573	27.557	28.542
30	29.526	30.510	31.494	32.478	33.463	34.447	35.431	36.415	37.399	38.384
40	39.368	40.352	41.336	42.320	43.305	44.289	45.273	46.257	47.241	48.226
50	49.210	50.194	51.178	52.162	53.147	54.131	55.115	56.099	57.083	58.068
60	59.052	60.036	61.020	62.004	62.989	63.973	64.957	65.941	66.925	67.910
70	68.894	69.878	70.862	71.846	72.831	73.815	74.799	75.783	76.767	77.752
80	78.736	79.720	80.704	81.688	82.672	83.657	84.641	85.625	86.609	87.593
90	88.578	89.562	90.546	91.530	92.514	93.499	94.483	95.467	96.451	97.435

TABLE XXXIV.—*For converting long tons (of 2,240 pounds each) into kilograms.*

(Divide the result by 1,000 for tonneaux or milliers.)

Long tons.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	1016	2032	3048	4064	5080	6096	7112	8128	9145
10	10161	11177	12193	13209	14225	15241	16257	17273	18289	19305
20	20321	21337	22353	23369	24385	25401	26417	27434	28450	29466
30	30482	31498	32514	33530	34546	35562	36578	37594	38610	39626
40	40642	41658	42674	43690	44707	45723	46739	47755	48771	49787
50	50803	51819	52835	53851	54867	55883	56899	57915	58931	59947
60	60963	61979	62996	64012	65028	66044	67060	68076	69092	70108
70	71124	72140	73156	74172	75188	76204	77220	78236	79252	80269
80	81285	82301	83317	84333	85349	86365	87381	88397	89413	90429
90	91445	92461	93477	94493	95509	96525	97542	98558	99574	100590

TABLE XXXV.—*For converting tonneaux or milliers into short tons, (of 2,000 pounds.)*

(To convert kilograms into short tons use this table and divide the result by 1,000.)

Tonneaux or milliers.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	1.102	2.205	3.307	4.409	5.512	6.614	7.716	8.818	9.921
10	11.023	12.125	13.228	14.330	15.432	16.535	17.637	18.739	19.841	20.944
20	22.046	23.148	24.251	25.353	26.455	27.558	28.660	29.762	30.864	31.967
30	33.069	34.171	35.274	36.376	37.478	38.581	39.683	40.785	41.887	42.990
40	44.092	45.194	46.297	47.399	48.501	49.604	50.706	51.808	52.910	54.013
50	55.115	56.217	57.320	58.422	59.524	60.627	61.729	62.831	63.933	65.036
60	66.138	67.240	68.343	69.445	70.547	71.650	72.752	73.854	74.956	76.059
70	77.161	78.263	79.366	80.468	81.570	82.673	83.775	84.877	85.979	87.082
80	88.184	89.286	90.389	91.491	92.593	93.696	94.798	95.900	97.002	98.105
90	99.207	100.309	101.412	102.514	103.616	104.719	105.821	106.923	108.025	109.128

TABLE XXXVI.—*For converting short tons (of 2,000 pounds each) into kilograms.*

(Divide the result by 1,000 for tonneaux or milliers.)

Short tons.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	907	1814	2722	3629	4536	5443	6350	7258	8165
10	9072	9979	10886	11794	12701	13608	14515	15422	16329	17237
20	18144	19051	19958	20865	21773	22680	23587	24494	25401	26309
30	27216	28123	29030	29937	30845	31752	32659	33566	34473	35381
40	36288	37195	38102	39009	39917	40824	41731	42638	43545	44453
50	45360	46267	47174	48081	48988	49896	50803	51710	52617	53524
60	54432	55339	56246	57153	58060	58968	59875	60782	61689	62596
70	63504	64411	65318	66225	67132	68040	68947	69854	70761	71668
80	72576	73483	74390	75297	76204	77111	78019	78926	79833	80740
90	81647	82555	83462	84369	85276	86183	87091	87998	88905	89812

TABLE XXXVII.—*For converting kilograms into avoirdupois pounds.*

Kilograms.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.841
10	22.046	24.251	26.455	28.660	30.864	33.069	35.274	37.478	39.683	41.887
20	44.092	46.297	48.501	50.706	52.910	55.115	57.320	59.524	61.729	63.933
30	66.138	68.343	70.547	72.752	74.956	77.161	79.366	81.570	83.775	85.979
40	88.184	90.389	92.593	94.798	97.002	99.207	101.412	103.616	105.821	108.025
50	110.230	112.435	114.639	116.844	119.048	121.253	123.458	125.662	127.867	130.071
60	132.276	134.481	136.685	138.890	141.094	143.299	145.504	147.708	149.913	152.117
70	154.322	156.527	158.731	160.936	163.140	165.345	167.550	169.754	171.959	174.163
80	176.368	178.573	180.777	182.982	185.186	187.391	189.596	191.800	194.005	196.209
90	198.414	200.619	202.823	205.028	207.232	209.437	211.642	213.846	216.051	218.255

TABLE XXXVIII.—*For converting avoirdupois pounds into grams.*

Pounds.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	454	907	1361	1814	2268	2722	3175	3629	4082
10	4536	4990	5443	5897	6350	6804	7258	7711	8165	8618
20	9072	9526	9979	10433	10886	11340	11794	12247	12701	13154
30	13608	14062	14515	14969	15422	15876	16329	16783	17237	17690
40	18144	18597	19051	19505	19958	20412	20865	21319	21773	22226
50	22680	23133	23587	24041	24494	24948	25401	25855	26309	26762
60	27216	27669	28123	28577	29030	29484	29937	30391	30845	31298
70	31752	32205	32659	33113	33566	34020	34473	34927	35381	35834
80	36288	36741	37195	37649	38102	38556	39009	39463	39917	40370
90	40824	41277	41731	42185	42638	43092	43545	43999	44453	44906

TABLE XXXIX.—*For converting kilograms into avoirdupois pounds and ounces.*

Kilograms.	0.	0.1.	0.2.	0.3.	0.4.	0.5.	0.6.	0.7.	0.8.	0.9.
	lbs. oz.	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*	*lbs. oz.*
0	0 0.0	0 3.5	0 7.1	0 10.6	0 14.1	1 1.6	1 5.2	1 8.7	1 12.2	1 15.7
1	2 3.3	2 6.8	2 10.3	2 13.9	3 1.4	3 4.9	3 8.4	3 12.0	3 15.5	4 3.0
2	4 6.5	4 10.1	4 13.6	5 1.1	5 4.7	5 8.2	5 11.7	5 15.2	6 2.8	6 6.3
3	6 9.8	6 13.3	7 0.9	7 4.4	7 7.9	7 11.5	7 15.0	8 2.5	8 6.0	8 9.6
4	8 13.1	9 0.6	9 4.1	9 7.7	9 11.2	9 14.7	10 2.3	10 5.8	10 9.3	10 12.8
5	11 0.4	11 3.9	11 7.4	11 11.0	11 14.5	12 2.0	12 5.5	12 9.1	12 12.6	13 0.1
6	13 3.6	13 7.2	13 10.7	13 14.2	14 1.8	14 5.3	14 8.8	14 12.3	14 15.9	15 3.4
7	15 6.9	15 10.4	15 14.0	16 1.5	16 5.0	16 8.6	16 12.1	16 15.6	17 3.1	17 6.7
8	17 10.2	17 13.7	18 1.2	18 4.8	18 8.3	18 11.8	18 15.4	19 2.9	19 6.4	19 9.9
9	19 13.5	20 1.0	20 4.5	20 8.0	20 11.6	20 15.1	21 2.6	21 6.2	21 9.7	21 13.2
10	22 0.7	22 4.3	22 7.8	22 11.3	22 14.8	23 2.4	23 5.9	23 9.4	23 13.0	24 0.5
11	24 4.0	24 7.5	24 11.1	24 14.6	25 2.1	25 5.6	25 9.2	25 12.7	26 0.2	26 3.8
12	26 7.3	26 10.8	26 14.3	27 1.9	27 5.4	27 8.9	27 12.4	28 0.0	28 3.5	28 7.0
13	28 10.6	28 14.1	29 1.6	29 5.1	29 8.7	29 12.2	29 15.7	30 3.2	30 6.8	30 10.3
14	30 13.8	31 1.4	31 4.9	31 8.4	31 11.9	31 15.5	32 3.0	32 6.5	32 10.0	32 13.6
15	33 1.1	33 4.6	33 8.2	33 11.7	33 15.2	34 2.7	34 6.3	34 9.8	34 13.3	35 0.9
16	35 4.4	35 7.9	35 11.4	35 15.0	36 2.5	36 6.0	36 9.5	36 13.1	37 0.6	37 4.1
17	37 7.7	37 11.2	37 14.7	38 2.2	38 5.8	38 9.3	38 12.8	39 0.3	39 3.9	39 7.4
18	39 10.9	39 14.5	40 2.0	40 5.5	40 9.0	40 12.6	41 0.1	41 3.6	41 7.1	41 10.7
19	41 14.2	42 1.7	42 5.3	42 8.8	42 12.3	42 15.8	43 3.4	43 6.9	43 10.4	43 13.9
20	44 1.5	44 5.0	44 8.5	44 12.1	44 15.6	45 3.1	45 6.6	45 10.2	45 13.7	46 1.2

TABLE XL.—*For converting avoirdupois pounds and ounces into grams.*

(Divide the result by 1,000 for kilograms.)

Avoir. pounds.	0.	1 oz.	2 oz.	3 oz.	4 oz.	5 oz.	6 oz.	7 oz.	8 oz.	9 oz.	10 oz.	11 oz.	12 oz.	13 oz.	14 oz.	15 oz.
0	0	28	57	85	113	142	170	198	227	255	283	312	340	369	397	425
1	454	482	510	539	567	595	624	652	680	709	737	765	794	822	850	879
2	907	936	964	992	1021	1049	1077	1106	1134	1162	1191	1219	1247	1276	1304	1332
3	1361	1389	1417	1446	1474	1503	1531	1559	1588	1616	1644	1673	1701	1729	1758	1786
4	1814	1843	1871	1899	1928	1956	1984	2013	2041	2070	2098	2126	2155	2183	2211	2240
5	2268	2296	2325	2353	2381	2410	2438	2466	2495	2523	2551	2580	2608	2637	2665	2693
6	2722	2750	2778	2807	2835	2863	2892	2920	2948	2977	3005	3034	3062	3090	3118	3147
7	3175	3204	3232	3260	3289	3317	3345	3374	3402	3430	3459	3487	3515	3544	3572	3600
8	3629	3657	3685	3714	3742	3771	3799	3827	3856	3884	3912	3941	3969	3997	4025	4054
9	4082	4111	4139	4167	4196	4224	4252	4281	4309	4338	4366	4394	4423	4451	4479	4508
10	4536	4564	4593	4621	4649	4678	4706	4734	4763	4791	4819	4848	4876	4905	4933	4961
11	4990	5018	5046	5075	5103	5131	5160	5188	5216	5245	5273	5301	5330	5358	5386	5415
12	5443	5472	5500	5528	5557	5585	5613	5642	5670	5698	5727	5755	5783	5812	5840	5868
13	5897	5925	5953	5982	6010	6039	6067	6095	6124	6152	6180	6209	6237	6265	6294	6322
14	6350	6379	6407	6435	6464	6492	6520	6549	6577	6606	6634	6662	6691	6719	6747	6776
15	6804	6832	6861	6889	6917	6946	6974	7002	7031	7059	7087	7116	7144	7173	7201	7229
16	7258	7286	7314	7343	7371	7399	7428	7456	7484	7513	7541	7569	7598	7626	7654	7683
17	7711	7740	7768	7796	7825	7853	7881	7910	7938	7966	7995	8023	8051	8080	8108	8136
18	8165	8193	8221	8250	8278	8307	8335	8363	8392	8420	8448	8477	8505	8533	8562	8590
19	8618	8647	8675	8703	8732	8760	8788	8817	8845	8874	8902	8930	8959	8987	9015	9044
20	9072	9100	9129	9157	9185	9214	9242	9270	9299	9327	9355	9384	9412	9441	9469	9497

TABLE XLI.—*For converting kilograms into avoirdupois ounces.*

Kilograms.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	35.3	70.5	105.8	141.1	176.4	211.6	246.9	282.2	317.5
10	352.7	388.0	423.3	458.6	493.8	529.1	564.4	599.7	634.9	670.2
20	705.5	740.7	776.0	811.3	846.6	881.8	917.1	952.4	987.7	1022.9
30	1058.2	1093.5	1128.8	1164.0	1199.3	1234.6	1269.8	1305.1	1340.4	1375.7
40	1410.9	1446.2	1481.5	1516.8	1552.0	1587.3	1622.6	1657.9	1693.1	1728.4
50	1763.7	1799.0	1834.2	1869.5	1904.8	1940.0	1975.3	2010.6	2045.9	2081.1
60	2116.4	2151.7	2187.0	2222.2	2257.5	2292.8	2328.1	2363.3	2398.6	2433.9
70	2469.2	2504.4	2539.7	2575.0	2610.2	2645.5	2680.8	2716.1	2751.3	2786.6
80	2821.9	2857.2	2892.4	2927.7	2963.0	2998.3	3033.5	3068.8	3104.1	3139.4
90	3174.6	3209.9	3245.2	3280.4	3315.7	3351.0	3386.3	3421.5	3456.8	3492.1

TABLE XLII.—*For converting avoirdupois ounces into grams.*

Av. ounces.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	28.3	56.7	85.0	113.4	141.7	170.1	198.4	226.8	255.1
10	283.5	311.8	340.2	368.5	396.9	425.2	453.6	481.9	510.3	538.6
20	567.0	595.3	623.7	652.0	680.4	708.7	737.1	765.4	793.8	822.1
30	850.5	878.8	907.2	935.5	963.8	992.2	1020.6	1048.9	1077.3	1105.6
40	1134.0	1162.3	1190.7	1219.0	1247.4	1275.7	1304.1	1332.4	1360.8	1389.1
50	1417.5	1445.8	1474.2	1502.5	1530.9	1559.2	1587.6	1615.9	1644.3	1672.6
60	1701.0	1729.3	1757.7	1786.0	1814.4	1842.7	1871.1	1899.4	1927.8	1956.1
70	1984.5	2012.8	2041.2	2069.5	2097.9	2126.2	2154.6	2182.9	2211.3	2239.6
80	2268.0	2296.3	2324.7	2353.0	2381.4	2409.7	2438.1	2466.4	2494.8	2523.1
90	2551.5	2579.8	2608.2	2636.5	2664.9	2693.2	2721.6	2749.9	2778.3	2806.6

TABLE XLIII.—*For converting kilograms into troy ounces.*

Kilograms.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	32.15	64.30	96.45	128.60	160.75	192.90	225.05	257.20	289.35
10	321.50	353.65	385.81	417.96	450.11	482.26	514.41	546.56	578.71	610.86
20	643.01	675.16	707.31	739.46	771.61	803.76	835.91	868.06	900.21	932.36
30	964.51	996.66	1028.81	1060.96	1093.11	1125.26	1157.42	1189.57	1221.72	1253.87
40	1286.02	1318.17	1350.32	1382.47	1414.62	1446.77	1478.92	1511.07	1543.22	1575.37
50	1607.52	1639.67	1671.82	1703.97	1736.12	1768.27	1800.42	1832.57	1864.72	1896.87
60	1929.03	1961.18	1993.33	2025.48	2057.63	2089.78	2121.93	2154.08	2186.23	2218.38
70	2250.53	2282.68	2314.83	2346.98	2379.13	2411.28	2443.43	2475.58	2507.73	2539.88
80	2572.03	2604.18	2636.33	2668.48	2700.64	2732.79	2764.94	2797.09	2829.24	2861.39
90	2893.54	2925.69	2957.84	2989.99	3022.14	3054.29	3086.44	3118.59	3150.74	3182.89

TABLE XLIV.—*For converting troy ounces into grams.*

Troy ounces.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	31.10	62.21	93.31	124.42	155.52	186.62	217.73	248.83	279.93
10	311.04	342.14	373.25	404.35	435.45	466.56	497.66	528.76	559.87	590.97
20	622.08	653.18	684.28	715.39	746.49	777.59	808.70	839.80	870.91	902.01
30	933.11	964.22	995.32	1026.43	1057.53	1089.63	1119.74	1150.84	1181.94	1213.05
40	1244.15	1275.26	1306.36	1337.46	1368.57	1399.67	1430.77	1461.88	1492.98	1524.09
50	1555.19	1586.29	1617.40	1648.50	1679.60	1710.71	1741.81	1772.92	1804.02	1835.13
60	1866.23	1897.33	1928.44	1959.54	1990.64	2021.75	2052.85	2083.95	2115.06	2146.16
70	2177.27	2208.37	2239.47	2270.58	2301.68	2332.78	2363.89	2394.99	2426.10	2457.20
80	2488.30	2519.41	2550.51	2581.62	2612.72	2643.82	2674.93	2706.03	2737.13	2768.24
90	2799.34	2830.45	2861.55	2892.65	2923.76	2954.86	2985.36	3017.07	3048.17	3079.28

TABLE XLV.—*For converting grams into grains.*

Grams.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	15.43	30.86	46.30	61.73	77.16	92.59	108.03	123.46	138.89
10	154.32	169.75	185.19	200.62	216.05	231.48	246.92	262.35	277.78	293.21
20	308.64	324.08	339.51	354.94	370.37	385.81	401.24	416.67	432.10	447.53
30	462.97	478.40	493.83	509.26	524.69	540.13	555.56	570.99	586.42	601.86
40	617.29	632.72	648.15	663.58	679.02	694.45	709.88	725.31	740.75	756.18
50	771.61	787.04	802.47	817.91	833.34	848.77	864.20	879.64	895.07	910.50
60	925.93	941.36	956.80	972.23	987.66	1003.09	1018.53	1033.96	1049.39	1064.82
70	1080.25	1095.69	1111.12	1126.55	1141.98	1157.42	1172.85	1188.28	1203.71	1219.14
80	1234.58	1250.01	1265.44	1280.87	1296.30	1311.74	1327.17	1342.60	1358.03	1373.47
90	1388.90	1404.33	1419.76	1435.19	1450.63	1466.06	1481.49	1496.92	1512.36	1527.79

TABLE XLVI.—*For converting grains into grams.*

Grains.	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
0	0	0.0648	0.1296	0.1944	0.2592	0.3240	0.3888	0.4536	0.5184	0.5832
10	0.6480	0.7128	0.7776	0.8424	0.9072	0.9720	1.0368	1.1016	1.1664	1.2312
20	1.2960	1.3608	1.4256	1.4904	1.5552	1.6200	1.6848	1.7496	1.8144	1.8792
30	1.9440	2.0088	2.0736	2.1384	2.2032	2.2680	2.3328	2.3976	2.4624	2.5272
40	2.5920	2.6568	2.7216	2.7864	2.8512	2.9160	2.9808	3.0456	3.1104	3.1752
50	3.2400	3.3048	3.3696	3.4344	3.4992	3.5640	3.6288	3.6936	3.7584	3.8232
60	3.8880	3.9528	4.0176	4.0824	4.1472	4.2120	4.2768	4.3416	4.4064	4.4712
70	4.5360	4.6008	4.6656	4.7304	4.7952	4.8600	4.9248	4.9896	5.0544	5.1192
80	5.1840	5.2488	5.3136	5.3784	5.4432	5.5080	5.5728	5.6376	5.7024	5.7672
90	5.8320	5.8968	5.9616	6.0264	6.0912	6.1560	6.2208	6.2856	6.3504	6.4152

AN ABBREVIATED TABLE OF THE METRIC SYSTEM

DEVISED BY C. W. FEARING.

	DIVISIONS OF UNIT			UNIT	MULTIPLES OF UNIT			NAME OF UNIT OF MEASURE	KIND OF MEASURE	EQUIVALENT OF UNIT OF MEASURE
Denomination Prefixes	MILLI-	CENTI-	DECI-		DEKA-	HEKTO-	KILO-			
Ratio to Unit	.001	.01	.1	1.	10.	100.	1000.			
Denomination Signs	**mm**	**cm** 0.3937 inch	dm	**m** 1.0936 yards	Dm	Hm	**Km** 0.6214 miles	METER	LENGTH	39.37 British Inches
	ml cubic centimeter	cl	**dl** 0.845 gills	**l** 1.0567 wine quarts	**Dl** 1.1340 pecks	**Hl** 2.837 bushels	Kl cubic meter	LITER	CAPACITY	One cubic decimeter
	mg	**cg** 0.1543 grains	dg	**g** 15.432 grains	**Dg** 0.3544 oz. avoir.	Hg	**Kg** 2.2046 lbs avoir.	GRAM	WEIGHT	One cubic centimeter of water at 4°centigrade(39°.2 Fahrenheit)
		ca		a		**Ha** 2.4711 acres		AR	LAND	One square dekameter
			dst	**st** 0.2759 cord	Dst			STER	WOOD	One cubic meter
	mill m	**cent ct**	dime di	**$**	eagle ea			DOLLAR	VALUE	26873 of standard silver, or 1s6718 of standard gold

EXPLANATION. Each denomination is represented by its abbreviation, or sign, and the full name may be found by combining the prefix over the sign with the name of the unit in the column at the right; as millimeter, liter, kilogram, hektar. The numbers in the line of *Ratio to Unit* show the relative value of each denomination beneath them to the unit of measure. Heavy type indicates the denominations mainly used.

NOTE. Surfaces and bulks are measured by the squares and cubes of the measures of length. Cubic centimeters are used instead of milliliters. For large weights a ton of 1000 kilograms is used.

Price 5c; $4 per 100. The Society for introducing the system (METRIC BUREAU, 32 Hawley St., Boston,) furnishes, at half price, this and all the best metric publications and aids to teaching

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THE METRIC SYSTEM.

LENGTH.

41.52 m. = 41.52 u.

	Kilo-	Km.	thousand.
	Hekto-	Hm.	hundred.
	Deka-	Dm.	ten.
4	METER.	m.	UNIT.
1	deci-	dm.	tenth.
5	centi-	cm.	hundredth.
2	milli-	mm.	thousandth.

SURFACE.

1723.9104 sq. m. = **LAND.**

	sq. Kilo-	sq. Km.	
	sq. Hekto-	sq. Hm.	Hektar.
1	sq. Deka-	sq. Dm.	AR.
7	SQ. METER.	sq. m.	centar.
2	sq. deci-	sq. dm.	
3	sq. centi-	sq. cm.	
9	sq. milli-	sq. mm.	
1			
0			
4			

VOLUME.

71576.759808 cu. m. = **WOOD.**

	Deka-		
7	STER.		
1	CU. METER.	cu. m.	
5	deci-		
7			
6			
7			
5			
9	cu. deci-	cu. dm.	
8			
0			
8	cu. centi-	cu. cm.	
	cu. milli-	cu. mm.	

WEIGHT.

TON.	
KILO-	Kg.
Hekto-	Hg.
Deka-	Dg.
GRAM.	g.
deci-	dg.
centi-	cg.
milli-	mg.

CAPACITY.

Kilo-	Kl.
Hekto-	Hl.
Deka-	Dl.
LITER.	l.
deci-	dl.
centi-	cl.
milli-	ml.

EXPLANATION AND NOTES.

KILO (1000), HEKTO (100), and DEKA (10), are Greek prefixes; DECI (.1), CENTI (.01), and MILLI (.001), are Latin prefixes.

The table of Length shows the correspondence between the metric and the common decimal system. Thus, instead of 4 dekameters, 1 meter, 5 decimeters and 2 centimeters, we read 41 meters 52 hundredths (or, better, omitting the final word, 41 meters 52); just as instead of 4 tens, 1 unit, 5 tenths, 2 hundredths, we read 41 (units understood) and 52 hundredths. See also tables of Weight and Capacity.

As indicated by the figures and spaces, each denomination of Surface measure requires two places; of Volume measure, three places. (Compare the "pointing off" principle of square and cube root.) All other denominations require one place. Thus, 1723.9104 sq. m. = 17.239104 sq. Dm., and 76.759808 cu. m. = 76759.808 cu. dm.

Equivalent or correspondiag denominations occupy the same horizontal line.

Thus, 1 sq. Dm. = 1 ar. 1 cu. dm. is the measure of a liter. 1 cu. cm. of pure water at 4° centigrade (39°.2 F.) weighs 1 gram.

1 meter = 39.37 inches nearly. 1 gram = 15.432 grains nearly.

1 liter = 1.06 liquid, or .908 dry quarts. 1 ar. = 119.6 sq. yards.

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To be obtained of the Metric Bureau, Boston. 5 cts. each. $3.00 per 100.

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The exact place on the page referred to is indicated in ninths by the superior figure; e.g., 194[7] means page 194, seven-ninths from top to bottom.

A colon, after the initial of a proper name, shows that it stands for the most common name beginning with that letter; e.g., G. H. Smith may have any given name beginning with G. and H., but G: H: Smith is *George Henry*. The list as recommended and used by the American Library Association, the official publications of the libraries and book trade, the *Library Journal* and the *Publishers' Weekly*, and many other cataloguers and indexers, is as follows:—

A: Augustus; B: Benjamin; C: Charles; D: David; E: Edward; F: Frederick; G: George; H: Henry; I: Isaac; J: John; K: Karl; L: Louis; M: Mark; N: Nicholas; O: Otto; P: Peter; R: Richard; S: Samuel; T: Thomas; W: William.

The words *metric* and *system* occur so often that they are abbreviated to m. and s. Other abbreviations, including those for the metric tables, will be self-explanatory.

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[Metric Circ. No. 5.]

"The Introduction of the International Decimal Weights and Measures."

AMERICAN METRIC BUREAU.

GENERAL OFFICES, 7 AND 8, SECOND STORY, 32 HAWLEY STREET, BOSTON

Note Particularly the Marked Paragraphs.

(1.) **This Circular.** — The constantly increasing interest in the work of this Bureau has repeatedly doubled its office-work. An assistant secretary was soon found necessary. A second assistant became equally necessary after another quarter; and now it is no longer possible for the secretary and two assistants to attend properly to the many applications from all parts of the country for information in regard to the international measures. Though the work has so much increased, it is not possible, with the limited funds at the disposal of the Bureau, to employ further assistance in the office, and, therefore, it has been determined to prepare this circular as the best practicable means of meeting the demands. It contains a series of statements which answer the questions most frequently asked by correspondents, and will be used as far as possible in replying to inquiries by marking the paragraphs in point and mailing, accompanied, if necessary, by an additional answer in manuscript. This method must be adopted, or a large portion of the inquiries must be entirely neglected, and the Bureau aims to furnish the desired information to every applicant.

(2) **The American Metric Bureau** was organized in the summer of 1876, by a number of educators desirous of hastening the introduction of the International Measures. Its general offices are in Boston (7 and 8, second story, 32 Hawley street), but its membership is scattered throughout the entire country, and it has quite a number of members in other countries where the metric system is already in use. The Bureau is incorporated by the State as "a missionary society for educational purposes." Though founded chiefly by practical educators, all professions and occupations are now represented in its membership, which is rapidly increasing. The object of the Bureau is to teach the American people what the metric system really is, and it is firmly believed that, as soon as that is accomplished, the system will come at once into general use. Art. 2 of its constitution sums up its object: —

"The object of this Bureau shall be to disseminate information concerning the metric system; to urge its early adoption; and to bring about actual introductions wherever practicable. To this end it will secure the delivery of addresses; publish articles; circulate books, pamphlets and charts; distribute scales and measures; introduce the practical teaching of the system in schools; and in all proper ways, as far as the means at its disposal will allow, the Bureau will urge the matter upon the attention of the American people till they shall join the rest of the world in the exclusive use of the International Decimal Weights and Measures."

(3) **The Bulletin** is the official publication, of sixteen pages, published monthly, and devoted entirely to the introduction, no advertisements being admitted. Its price is $1.00 per year. Matter once printed in this form cannot be repeated in correspondence or in circulars, and, therefore, it becomes of the first importance that each correspondent should have a complete set of

the Bulletin for reference. To insure this the committee offer to send the volumes now out, bound and indexed, to any address on receipt of fifty cents each to pay for binding and postage. This offer is made with the view of placing bound and indexed Bulletins in the hands of all friends of the system, where they will be preserved and can be easily consulted by all interested. Reference will be freely made to its pages, with the understanding that copies are accessible to each correspondent. (Bul., p. 3–5.) 1876 has 96 pages. 1877, 144

(4.) **Publications.** — The best books, articles in periodicals, etc., will be mentioned in the Bulletins from month to month, with brief notes as to their character. All the best can be had at the Bureau, either gratuitously or at one-half regular price. The Bureau also publishes, for the use of its members, and others interested, large and small charts of the system, giving full-sized drawings of the weights and measures, tables, equivalents, etc. Posters, briefly explaining some of the advantages of the system, and giving information in a popular form, will also be provided; also, letter-heads, tables for the backs of envelopes, etc., etc. Anything of this kind prepared by the Publication Committee will be sent at half-price to any member of the Bureau desiring to use it for helping forward the introduction. (See each Bulletin under the head PUBLICATION.)

(5.) **Progress.** — Adoptions or endorsements of the system by societies, schools, factories, stores, etc., are noticed under this head in each issue of the Bulletin. The record is very incomplete, because information is not sent to the office and the fact escapes attention; still there is a constantly increasing number of adoptions. (See each Bulletin under head PROGRESS.)

(6.) **Membership** in the Bureau is specially important. The plan has been to make membership desirable by giving various privileges, and to remove all objections of a pecuniary nature. There is no fee for joining the Bureau, but each member is liable to an assessment once each calendar year for his share of printing and stationery. Further than this there are no required fees or dues, and the constitution distinctly provides that there can be no other liabilities of membership. The Bureau asks donations from all interested, whether members or not, and leaves it wholly with each one to determine what they can afford to give to help the cause. Each member receives at once, on publication, and without expense, all charts, books, Bulletins, circulars, etc., which are issued on the subject, — these coming from the trustees', and other funds subscribed for the purpose. As the price of the publications is and will be considerably more than the assessment, membership is practically without expense, except such amount as each may choose to give.

Every person desiring to see the metric system introduced into general use is eligible to membership, and every such person is cordially invited to become a member of the Bureau. Formal invitations are extended to those whose names are sent to the Membership Committee as probably interested in the work, but it is expected that those desiring to be recorded as in favor of the system will send in their names, as soon as they know of the character of the Bureau, without waiting for formal invitation. (Bul., p. 30, 50.)

(7.) **Subscribing Membership.** — This provides for any who favor the system, but, from special reasons, are unwilling to lay themselves liable to even a slight annual assessment. This new membership was devised so that every friend of the system might be recorded on our roll. For the reasons given (Bul., p. 48), subscribing members receive the monthly Bulletin, and are charged its actual cost and postage, which together amount to about eight cents per month.

(8.) **Income.** — The Bureau has no income except the slight assessment of its members for printing and stationery, and voluntary subscriptions. The

supply of metric articles conducted by the Trustees of the Sinking Fund is entirely distinct from the society proper. The Supply Department is in charge of an independent Board of Trustees, who use every proper effort to distribute the largest possible number of metric measures, etc., and still make the department self-supporting, for they must meet their own bills or supplement deficiencies by special contributions for the purpose. The Sinking Fund neither receives from the Bureau or affords to it pecuniary aid. It, therefore, depends almost entirely for its support on the donations of friends. The assessment of members being simply for printing and stationery is kept as low as possible (last year $2.50). There is opportunity for the friends of the system to accomplish, through the agency of the Bureau, with such money as they are willing to expend in advancing the introduction, tenfold more than could be accomplished by the same money under ordinary circumstances. Although the Society is accomplishing very much, the work is crippled and embarrassed for want of funds, and every one who wishes it to succeed should give something, however small, to the general treasury or to any special object desired. (Bul., p. 49, 60, 128.)

(9.) **Remittances** are made at the risk of the sender in all cases, though the Bureau has never yet lost anything in the mails. If drafts and orders are sent, they should, for convenience, be made payable to the Secretary's order.

(10.) **Full information** on points not mentioned in this circular should be sought in the best metric publications. It is, of course, impossible for the secretary to give, in reply to many questions, as full information as is desirable. One asks for the history of the system; another for a set of tables; another for a summary of the arguments for and against, etc. We can only refer friends to the books where what is wanted is given. It is impossible for a society like the Bureau to attempt gratuitous distribution of such publications, for the demand would exhaust the funds almost immediately. The plan has therefore been adopted of sending all the best metric publications at half price to those who are anxious to investigate the system. It is believed that those who are enough interested to be of any value to the cause will be glad to pay one-half the cost of the necessary books; and it seems much better that one hundred people should be supplied at half price rather than fifty people gratuitously and the rest not at all. A list of the best publications, with notes as to their character, will be sent to applicants enclosing stamp.

(11.) **Actual Weights and Measures** have been in the market for some time, but at prices so high that few could afford them. Everything now wanted is furnished, by the Trustees of the Sinking Fund of the Bureau, at prices from one-fifth what they have heretofore cost, upward. How this is possible is fully explained in the December Bulletin, p. 64–96, with the full list of articles and the cost of each. The numbers containing the history of the Sinking Fund, description, prices, etc., will be sent post free for half price, ten cents. The trustees have now over five hundred different metric articles, their collection being vastly larger than any other in the country.

(12.) **The work to be done by individuals** friendly to the introduction is, after all, the chief thing. If you wish this country to enjoy the vast advantages of the system as soon as practicable, you have a personal duty.

First, you must *understand the system thoroughly yourself.* Very many who claim to know all about it have erroneous ideas on some points, and it is a great misfortune to have these ideas propagated. Be sure you understand it yourself, and then use it wherever and whenever practicable. (Bul., p. 67.)

Your next duty is to induce others to understand and use it. To this end, if

you ever speak or read in public, prepare a popular account and explanation of the system, and give it before such an audience as you have. It pays to do this before any audience, from the national congress to the primary class in the district school, and especially if you are able to illustrate your lecture with simple apparatus or the actual metric measures. Such lectures, even when given by those who have never spoken in public, are found to be of great interest to those who hear them, and members of the Bureau who have prepared such a talk for some school or lyceum, find themselves called upon to repeat it in neighboring towns and before other associations. If you cannot do this yourself, see to it that the most competent person in your community does do it.

Equally important is the press. Articles or paragraphs on the subject will be gladly printed by any respectable journal, and will have a large influence in familiarizing the public with the international measures. Be careful here, as in the lecture, to give only correct explanations. If each individual will understand and use the system himself, and, when opportunity offers, speak or write of its merits, we shall carry the introduction forward very rapidly. Personal explanation to friends is, perhaps, an even more powerful agency in building up the work; and remember, when interest in the subject is professed, to invite those friends to join with other workers in the Bureau.

(13.) **Introductions.** The Bureau is in constant receipt of applications for cabinets of metric measures for fairs, institutes, etc.; for charts to hang in post-offices, R. R. stations, and other public places; for books, pamphlets and circulars to distribute among those interested. While greatly desiring to send these things, the limited fund makes it impossible. Such applications are so very numerous that many thousands of dollars would be required annually, to respond to them. The Bureau aims to excite interest, and guide the movement as much as possible, but it must be sustained in each section by its friends in that section. All necessary articles can be obtained from the general office at about half price. This half must, however, be secured for each application, by the friends of that application. A little effort will, almost uniformly, secure the small amount needed. If you want charts for certain prominent windows, ask the people, who are interested in having them hung there, to contribute their share towards the necessary half price.

A moment's thought will convince any friend of the reform that it is much better to furnish all that apply at half price, than to furnish a few of the first gratuitously, and the rest not at all. The Bureau aims to help, as much as possible, the sections where there are those willing to help themselves. The introduction of the metric system is not a thing from which some one is to derive a profit, as from the introduction of a school-book, or a new article of food or dress. The matter is one of direct interest and value to each community and individual, and each should make some effort to secure its advantages, not waiting to have them thrust upon him.

The correspondence of the Bureau is so very large that the single item of postage is a heavy expense. While inquiries will be answered just as promptly though no stamps are enclosed, friends are reminded that the Bureau has no selfish objects to be gained, as have the ordinary business houses, and therefore even small items of expense should be considered in its favor as much as possible.

Donations of even the smallest amounts will be gratefully received, and used for promoting the introduction, in accordance with the directions.

All communications should be addressed to the General Office.

P.O. 260, Boston. MELVIL DEWEY, *Secretary.*

[Metric Circ. No. 8.]

AMERICAN METRIC BUREAU.

[Melvil Dewey, Secretary.]

GENERAL OFFICE, 32 HAWLEY STREET, BOSTON.

To the School Officers and Teachers of the United States: —

At its recent quarterly meeting at the Massachusetts Institute of Technology, the American Metric Bureau appointed a special committee, with instructions to prepare for the school officers of the country a brief statement of the educational value of the metric system, and its importance to the schools; and to urge the imperative necessity of thoroughly teaching it in all the grades. In accordance with this appointment, the committee requests your careful consideration of the following points: —

This country has now come to a stage in the introduction of the international weights and measures where, in the judgment of those most familiar with the facts, the honor of bringing it to an early completion, or the responsibility of delaying it for many years with all the attendant confusion and expense, rests almost entirely with the schools. The necessary laws have been enacted; the matter has been pressed upon public attention; both legislators and business men agree that the only thing necessary to complete the work is a few years' thorough teaching of the system. Until this is done, further legislation and adoptions by factories and business firms lose half their influence. The great work has been carried forward to the doors of the schools, and though many of the foremost have already practically recognized their duty, we shall be debarred from most of the immense advantages, both educational and economical, until this leading shall be generally followed throughout the entire country.

Indeed, the new measures have made so much headway, and are so often used in books and periodicals, and in actual business, that they need to be fully understood by all our people. Therefore, until the complete introduction is effected, we must teach and use *both* the metric system and the clumsy English system, or rather lack of system.

This appeal is made with the belief that, as soon as the facts are fully understood, all the more intelligent and active educators will join in a determined effort to give the necessary practical instruction in the schools. Apart from its claims as a system of weights and measures, there are educational reasons quite sufficient to justify the most earnest efforts for introducing the study.

1. Careful computation of the result of completely replacing the present weights and measures in our arithmetics by the metric, *gives a saving of a full year in the school life of every child educated.* This startling statement has been repeatedly examined by practical teachers, who have, thus far, without

exception, arrived at the same conclusion. When it is remembered that it is impossible to get time for the various branches which it seems desirable to teach in the public schools, the vast importance of this saving will be apparent. It points to a possibility of giving some attention to subjects for which so strong arguments have been advanced, but for which the most friendly school government has often found it impracticable to provide the time, — physiology, elementary science, industrial art, music, drawing. The proposed teaching of the international measures requires but a very limited time, and will in the end save that time over and over again.

2. Beside the all-important saving of time, the metric measures should be introduced into the schools as one of the most perfect appliances known for teaching arithmetic to beginners. In the best school systems, it has been found of great advantage to teach a child our decimal arithmetic through tangible objects. The law of progression from lower to higher units, addition, subtraction, multiplication, and division, are all made object lessons by means of the metric measures of length and capacity. The metric square and cubic measures illustrate evolution and involution. Every teacher of experience, recognizing the exact correspondence of the tangible measures of the metric system with the numbers and laws of simple arithmetic, will see how valuable an aid is here afforded. Lessons impressed by seeing and handling the objects are known to be infinitely more enduring than mere statements, and the thorough teaching of the metric system is, therefore, urged as being an introduction of tangible arithmetic. The units, tens and hundreds of the actual measures are identical with those of the Arabic numbers; one is an abstraction, the other may be seen and felt.

3. The metric system is, without doubt, the best possible introduction to our present weights and measures, *i.e.*, to compound numbers. If of no other value, it merits the very small amount of time required, as the most efficient means of giving a clear comprehension of their theory. The wonderful simplicity of the system makes it possible for the youngest pupil to understand the underlying principles of measures. These once fixed in mind, he is able after a time to take up the confusion of our old system with an idea of what measures are, such as could not have been conveyed except through this method. Teachers will see at once the advantage of teaching first the simple and regular, until the mind grasps the idea, and then going on to the exceptional and irregular.

4. As the metric multiples correspond perfectly with whole numbers, so the metric fractional units agree with what we term decimals. Decimals may be handled and seen, and the difficulties sometimes experienced in making younger pupils understand their laws will be largely obviated when these laws are made object-lessons through the decimal measures.

The committee has given only educational reasons for the step proposed, reasons which are seldom brought into prominence except by teachers. There has been no mention of the greater arguments, of economy in commercial and international relations, and the fact that the general adoption of the system by

this country is recognized, even by its opponents, as one of the inevitable events of the future.

It is supposed that many teachers are already familiar with the facts, and are prepared to explain to others, how the adoption of the international measures will save so many millions annually, and also why the adoption is considered inevitable by those familiar with all the bearings of the subject. To those desiring, the Secretary of the Bureau will gladly send further information on these points.

The object of the present appeal is to call the attention of school officers and teachers to their duty to the schools and to the country, by which they are employed to select and teach that which will be most useful and profitable.

As has been briefly pointed out above, the metric system is wanted in the schools as a means to the best arithmetical teaching; but it interests educators chiefly as practically giving what is more important than money or methods, — a year of school life to each child. It is demanded of the schools as something that will in the end save many millions annually to the country. As this is called to the attention of the people, they ask, "Why is this not used among us, and why is it not taught in our schools more thoroughly?" It is preëminently the teacher's work to explain these matters to the public. He must explain them to his pupils, and having of necessity prepared himself for the duty, he should be willing to help all interested to understand the advantages to be derived from the general adoption of the new measures. Certainly this work falls to no class in the community, if not to the teachers. They will be seconded heartily by the educated classes, but it naturally falls to them to lead such an agitation.

In conversation, in literary societies, in clubs, in the local papers, wherever fitting opportunity presents itself, they should make plain to those desiring the knowledge, how the international measures will save time and money and patience, and eliminate the greatest source of confusion and fraud, as the testimony of all past commerce proves. They should be able to answer all inquiries regarding the spelling, pronunciation, and abbreviation of the terms, and to give information as to the denominations most in use. To master all these points requires but a few hours' time, and there is no excuse for teaching the metric system incorrectly in any of the particulars cited.

Without guidance those taking up the measures are, of course, apt to fall into mistakes; just as a foreigner depending on our printed tables of federal money is as liable to express quantities in eagles and dimes as in dollars and cents.

The teacher must first understand his subject thoroughly himself; then, in his teaching, something more than mere statements of the facts will be found necessary to any high degree of success. The instruction must be practical. Experience in the countries where the system has been many years in use, and specially in those like Germany, that have recently introduced it, points out clearly the practical and successful method, and American teachers should profit by this experience. The advocates of the introduction have made it possible to obtain any needed information, appliances, or illustrations at a mini-

mum of cost and trouble, and there is no longer any valid reason why the most thorough instruction should not be given in the schools, both public and private, and of all grades.

The growing number of high schools and colleges that require for admission as thorough a knowledge of the metric system as of any other part of the arithmetic makes its teaching a necessity in the higher grades. The reasons adduced in this circular must make it clear that this work should have been done in the lower grades. If properly taught to the younger classes, no time will be required when they become in due course the older classes.

Duty to the schools under their charge and to their constituency requires this instruction from school officers. To those whose interest is greater than mere duty, a most cordial invitation is extended to join in the organized movement for teaching the people at large what the international measures are; for this being understood by the masses, the introduction will follow without much special effort. Information as to the work of the Bureau, the conditions of membership, etc., will be gladly sent to any who may apply to the general office or to any of the depositories.

School officers desiring fuller facts regarding the methods most approved in other countries, or any other information pertaining to the the teaching, introduction, or use of the International Decimal Weights and Measures, are cordially invited to communicate with the Secretary, MELVIL DEWEY, at the General Office, 32 Hawley Street, Boston.

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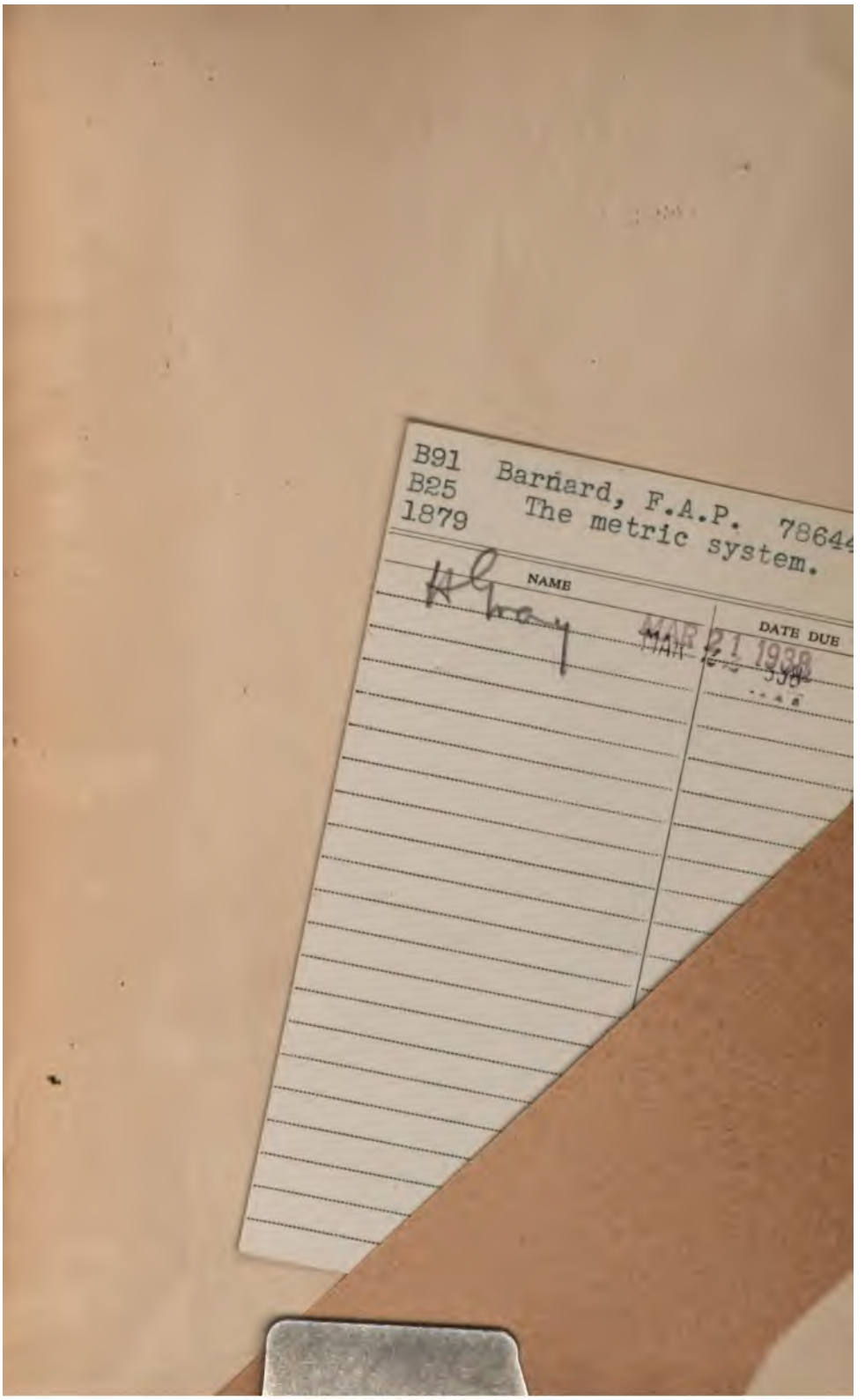
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